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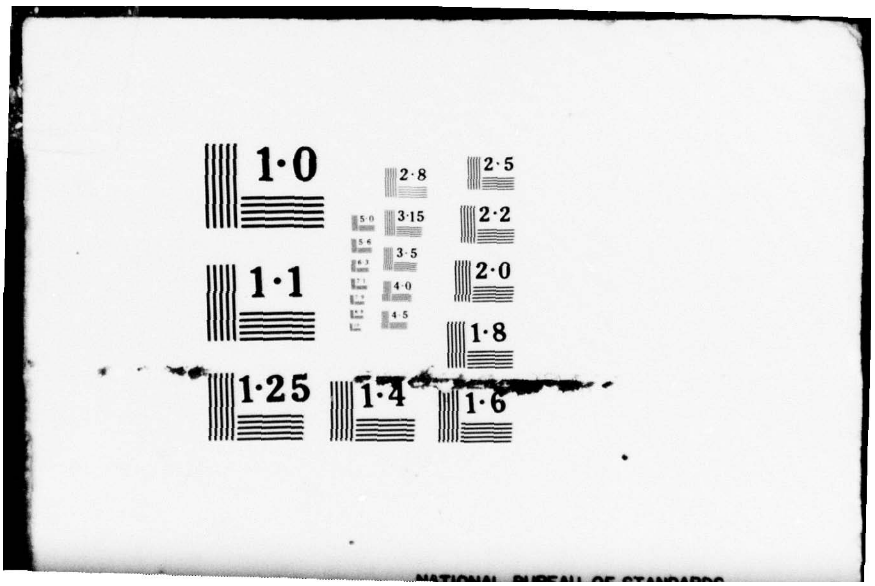
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DIRECTOR NOTES

I am writing these notes in West Berlin, where I am attending a meeting of ISO TC 108, a committee concerned with international standards on vibration and shock. The readers may have noticed reports in this Digest on progress of this and other standards organizations, both in the United States and on an international level. At the Berlin meeting six working groups of TC 108 have been convened, along with about ten working groups under three of the four independent subcommittees. Intensive working sessions are scheduled over a period of eight days. I am once again impressed with the talent and dedication of the delegates from the many nations involved.

The obvious benefits from such meetings are the standards, which are frequently vital to international commerce. Not so obvious are the intangible benefits -- the international exchange of technical information and ideas on an informal basis. One cannot measure directly the value of such exchanges, but it is clear that there are significant benefits to both the participants and the organizations they represent.

The documents produced by such ISO committees as TC 108 often have uses extending beyond their principal application in the standards area. For example, TC 108 standards are frequently used as guidelines because they reflect an international consensus on procedures relating to dynamic analysis or testing. Such documents can be advantageously used by investigators whether or not they are concerned with a product on the international market. However, those documents cannot be written without the cooperation of competent technical representatives of member countries. I would therefore urge those of you with interest and opportunity to offer your services in international standardization programs.

H.C.P.

EDITORS RATTLE SPACE

PRODUCT LIABILITY - THE GOOD SIDE

During the recent wave of threats of and actual product liability law suits engineers have become newsworthy. Perhaps this is not the recognition desired, nevertheless, it is here for good or bad. There is a good side to all this publicity and apparent trouble -- more often than not the engineer will be given the opportunity to do a good job.

Countless times engineers have complained to me that management does not schedule enough time to adequately design, analyze, or test a new product. A fellow engineer can only agree because each of us has been under constraints. A wise engineer will not depend on insurance or some equally costly measure to avoid product liability problems, but will utilize his engineering and communications talents. He will insist on enough time to engineer and document his work.

A better job on new products -- even if it is only better documentation of design and test results -- means increased costs to the public. However the cost is worthwhile in terms of increased product safety. Of course the design engineer has little control over the compromises made by so-called packaging and product engineers. If these cost-cutting measures are not reviewed by the design engineer, little will be accomplished insofar as upgrading the design process is concerned.

The increased emphasis on engineering that should result from product liability lawsuits does not mean that the engineer should have unlimited time and money for design, analysis, and testing. He must still be responsible for providing cost effective engineering to his employer or client. In addition, he should be prepared to document the hazards and probability that accidents will occur from an inadequately designed product.

R.L.E.

BAND SAW VIBRATION AND STABILITY

A.G. Ulsoy* and C.D. Mote, Jr.*

Abstract - This paper evaluates the most significant research achievements reported in the international band saw vibration and stability literature. Fundamental research developments in vibrations that are useful in other areas of research, as well as active and potentially fruitful research areas, are emphasized.

A previous literature review described various topics, including vibration of pipes transporting fluids, axially moving strings and threadlines, moving chains, band saws, high-speed tapes, and belts [59]. Since that time, progress in such areas as conduit dynamics has created the need for more narrowly focused reviews. This review examines fundamental investigations of band saw vibration and stability. The literature is widespread in journals and reports in a variety of languages, and considerable duplication of effort has occurred. All pertinent papers known to the authors are reviewed in the following pages.

IMPORTANCE OF VIBRATION

Rising raw material and labor costs in recent years have stimulated interest in improved sawing practices. A high cutting rate is still among the most desired characteristics, but other factors are becoming increasingly important: improved cutting accuracy and surface quality and reduced raw material losses, noise downtime, and maintenance. The essential features of circular saw vibration have been theoretically analyzed and experimentally verified [65]; however, research in band saw vibration and stability is less advanced. Band saws have certain advantages over circular saws: higher cutting speeds, less raw material waste, and typically lower noise levels [46, 113]. The use of band saws in the wood industry has increased steadily since 1920 [70]. Today band saws are used for many operations, from primary log conversion to furniture manufacture.

Raw material losses can be reduced by using thinner blades, so long as blade vibration is controlled and blade stability maintained. Blade instabilities result in poor cutting performance and catastrophic blade failures. Although some vibratinn cutter techniques have been proposed [98], saw vibration is generally undesirable. Several investigations of the effects of blade vibration on cutting accuracy and surface quality have been published. Birkeland [16] concluded that most sawing inaccuracies are traceable to carriage motion and that the depth of cut does not influence cutting accuracy; he did not investigate blade vibration. Thunnell [102] noted that the effect of feed speed on dimensional accuracy is fairly small until a critical feed speed is reached; above this speed accuracy rapidly deteriorates. It may be that blade buckling occurs at a critical edge load. Breznjak and Moen [17] concluded from wood sawing experiments that variation in lumber thickness, energy consumption, and raw material losses increased with increasing vibration amplitudes; lateral vibration increased with increasing clearance between blade and saw guides and with increasing feed speed; and surface quality improved as high frequency vibration increased during surface polishing of the workpiece.

BAND SAWING PROCESS

A modern bandmill and a schematic representation of a band saw indicating the important geometric and process parameters are shown in Figures 1 and 2 respectively. From the point of view of stability, the important parameters are the band axial tension (R), the free length between guides (ℓ), the types of guides, the cutting force components (normal, F_n; tangential, F_t; and transverse, F_b), band thickness (h), and band width (b). Lateral forces due to blade-workpiece interactions, wheel irregularities and eccentricities, band irregularities, and the state of stress of the blade during operation are also important.

The stress in the blade is particularly important with regard to vibration and stability. Blade stresses arise from band axial tension [47, 79], bending over

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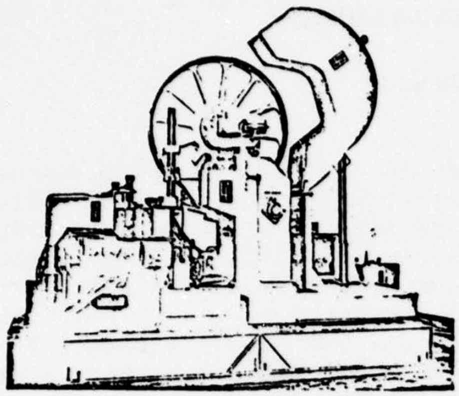


Figure 1. Photograph of a Production Bandmill [courtesy Kockums Letson and Burpee Ltd.]

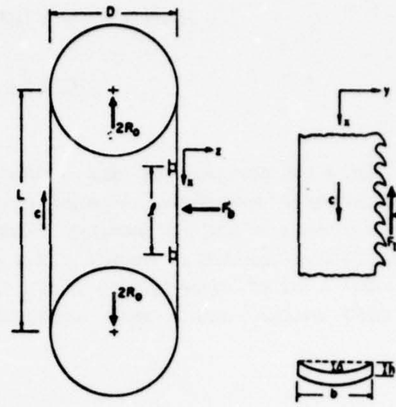


Figure 2. Schematic Representation of a Bandsaw

the wheels [73, 103], pre-stressing operations [109, 114], centrifugal forces [73, 79], cutting forces [47, 103], thermal effects [86, 96], and cutting or punching the teeth [112, 115]. Typical stress magnitudes in an idling band saw blade are summarized in *Table 1*. *Allen* [5, 6] presented experimental data showing that the standard deviation of the thickness of boards decreases with increasing band axial tension; this phenomenon is commonly referred to as strain. The trend toward high tension bandmills results from the desirability of increasing effective blade stiffness [3, 4, 21, 79].

The large cyclic bending stresses shown in Table 1 are known to be the main cause of band-saw fatigue failures and gullet cracking problems [39, 40, 79, 110, 111]. The maximum bending stress is approximately proportional to the band thickness-wheel diameter ratio (h/D); thus these stresses decrease when large diameter wheels and thin blades are used.

A pre-stressing procedure, commonly referred to as tensioning, is used in the forest products industry. The saw blade is stiffened by introducing favorable in-plane residual stresses. Local plastic deformation is produced by hammering, rolling, or heating the blade. Although initial stressing of the band saw has been used since the end of the 19th century, com-

Table 1. Stresses in Band Saws

Stress Component	Stress Magnitude, N/mm^2 Normal "Strain"	High "Strain"	Sources
Bending σ_B	210-240	110-130	47, 73, 79
Centrifugal σ_C	7-20	7-20	73, 79
"Strain" or Axial Tension σ_S	40-80	80-140	30, 47, 73 79, 95
"Tensioning" or Pre-stressing σ_T	35-70	35-70	47, 79

plete control of the initial stressing process has not yet been fully attained. It is important that the optimal residual stress state be estimated and introduced so that maximum cutting performance is obtained without overstressing the blades; such overstressing causes fatigue and gullet cracking problems. Accurate measurement of initial stresses is difficult, and the values reported in Table 1 should be considered approximate. The initial stressing process (Fig. 2) deflects the transverse shape of the blade [26]. Aoyama [11-13] concluded that this deflected shape depends upon blade geometry, the number and location of rolling passes, and roller geometry and pressure. Even though transverse deflection profiles of two blades may be similar, the corresponding band stress distributions can be very dissimilar. The light gap technique of sensing the shape thus cannot provide an accurate estimate of residual stresses [34].

EQUATION OF MOTION

In the earliest analyses of the band saw vibration problem the blade was modeled as an axially moving beam [53, 62]. The undamped equation of transverse motion is

$$m\,w,_{tt} + 2mc\,w,_{xt} + (mc^2 - R(c,t))\,w,_{xx} + EI\,w,_{xxxx} = 0 \qquad (1)$$

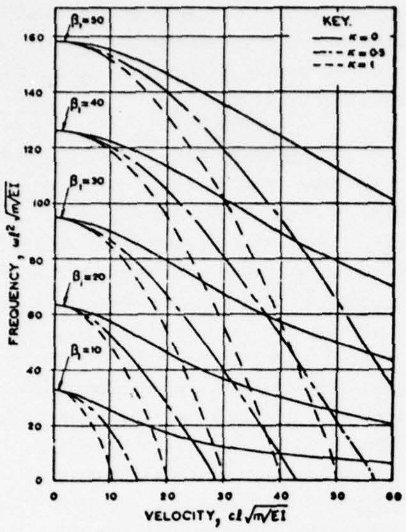
The subscripts denote partial derivatives with respect to time and length, m is the mass per unit length, c is the constant band transport velocity, R(c, t) is the velocity dependent band axial tension or strain, and EI is the flexural stiffness. A physical interpretation of the terms in equation (1) has been given [59] for band saws, belts, and conduits. Other linear formulations include a Timoshenko beam model [91]. A technical discussion of torsional vibration has been published [7, 93].

The boundary conditions for equation (1) are associated with the wheels -- or guides when they are present. The classical pinned-pinned or clamped-clamped conditions are usually chosen. The band response is influenced by such factors as disturbances and band motions outside the cutting region and between the guides and wheel shape. These factors propagate energy into and out of the cutting region. Band response is therefore determined by the design and excitation of the entire band, not just the segment between the guides. Anderson [8] studied the multiple support problem; he also noted that the pinned-pinned vs clamped-clamped support assumptions do not greatly influence the first few natural frequencies of the band.

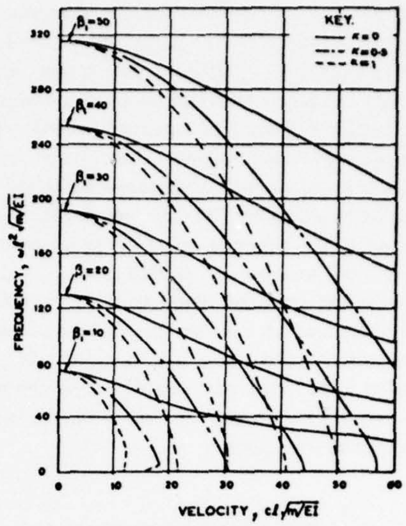
Both the classical and original analytical techniques that have been used to solve the problem of the transverse motion of the moving band have been discussed [59]. The finite element-Galerkin method has also been used [8], and for the related problem of strings or beams subjected to moving forces, transform methods have been used [36, 84]. The forced and free vibration response of moving strings -- including the influence of transport velocity (c) in equation (1) -- have been investigated [63, 83, 97]. Beam models usually relate the natural frequencies of the band to the axial transport velocity; the transverse response is not explicitly determined (Fig. 3). Experimental studies showed good agreement with theory at low to moderate transport velocities [44, 62]. The band saw does not have natural frequencies in the classical sense; that is, no single frequency in phase oscillation is possible for $c \neq 0$. The excitation frequencies that do exist cause solutions of the linear, undamped equation of band transverse motion to become unbounded for finite excitation amplitudes. It is these frequencies that are referred to in the literature as the natural frequencies of the band saw.

The transverse vibration of a band saw induced by a periodic axial tension or parametric excitation during operation has been considered [49, 53, 56, 58, 68, 81]. Band saw buckling by cutting edge loads has been investigated and parametric excitation and edge load buckling briefly discussed [7, 35, 57, 93].

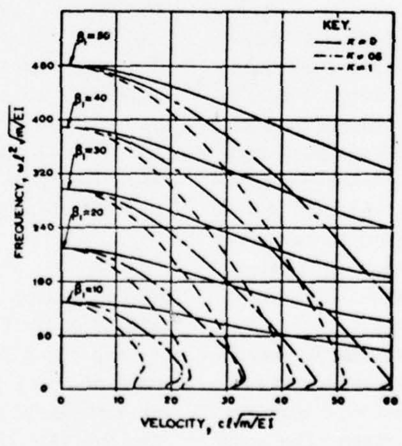
The extensions of the equation of motion to include additional nonlinear terms have been mostly for moving string models ($EI, w_{xxxx} = 0$) and have been discussed [59]. The method of characteristics has been used to analyze the planar nonlinear string problem [41]. Results for the general case of three-dimensional nonlinear string motion [89] agree with experimental observations [9]. An algorithm for a numerical solution to the nonlinear threadline equation has been presented [66]. Some attention [92, 100, 105, 106] has been given to nonlinear axially moving beam problems ($EI \neq 0$). One general conclusion of the nonlinear analyses has been that the



(a) First Natural Frequency vs Band Velocity



(b) Second Natural Frequency vs Band Velocity



(c) Third Natural Frequency vs Band Velocity

Figure 3. Relationship of Natural Frequencies of the Band and Axial Transport Velocity [53] ($\beta_1 = \ell\sqrt{R_0/EI}$)

relative importance of the nonlinear terms in the equation of motion increases as the transport velocity (c) increases. Linear analyses are thus restricted to small transverse displacements and to a low to moderate transport velocity range [55]. Curves are available for estimating the accuracy of the linear period and for comparing linear and nonlinear modes of oscillation in strings and beams [63, 105, 106].

The contributions of linear damping to the response of an axially moving string have been studied [51, 83]. Mahalingam [51] concluded that a linear damping term $\beta(c\,w_{,x} + w_{,t})$ gave results closer to experimental observations than $\beta w_{,t}$, but little attention has been directed to the question of damping.

The axial tension of the band as formulated by Chubachi [20] and Mote [53, 54] is dependent on the band axial velocity (c) and possibly time.

$$R(c,t) = R_0(t) + \eta mc^2 = R_0(t) + (1-\kappa)mc^2 \qquad (2)$$

$R_0(t)$, the tension caused by wheel position and wheel shape, is the initial static tension in the band for $c = 0$ and is a periodic function of time for rotating eccentric and noncircular wheels. The second term in equation (2) -- involving η or κ -- results from the normal acceleration of the band at the wheels. The dynamic component of the band tension required to accelerate the band around the wheels does not cause interaction between the band and the contiguous wheel. The static tension component is induced by band-wheel interaction. The dynamic tension is therefore not supported at the wheel axle. For wheels loaded with a dead weight system -- the mechanical equivalent to applying tension with an infinitely soft spring -- the dynamic tension is superimposed on the initial static tension R_0. The tension increase with speed is at a maximum when $\eta = 1$ or $\kappa = 0$. With κ in the range $0 \leq \kappa \leq 1$, $\kappa = 0$ corresponds to an infinitely soft spring mounting; in Figure 4 $\kappa = 1$ corresponds to a rigid spring [53, 54, 62]. Most likely the dead weight tension system has been successful in practice because it creates a maximum operating tension and, accordingly, maximum natural frequencies for the band at a given R_0.

Blade-guide interactions in band saws are not well understood and require further investigation. Contacting pressure guides are widely used in saw mills; guides with a small clearance and roller type guides are also used [27]. Other guide designs are being investigated. The simple support boundary condition assumption of the band at the guides, used in conjunction with equation (1), is approximate because the bending moment at the guides does not vanish. An extensive literature exists on the problem of an elastic strip or band responding to such moving loads as guides, cutting forces, and saw-workpiece interaction [2, 19, 32, 36, 48, 107, 108].

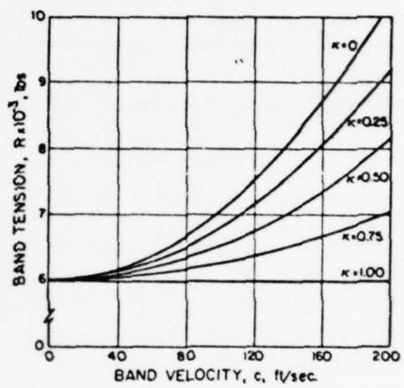


Figure 4. Band Tension -- Velocity Dependence for Five Pulley Mounting Systems [54]

The total mechanical energy of the portion of the moving band between the guides is the sum of the kinetic energy of vibration and the strain energy of deformation of the segment of the band; the mechanical energy is never constant even for a model with conservative external loading and zero damping [59]. During periodic motion a continuous, periodic transfer of energy takes place into and out of the region between the guides. This means that the band transverse response amplitude for $c \neq 0$ in equation (1) can be much larger than if $c = 0$ for the same initial conditions. The importance of this phenomenon is that a relatively small excitation, say from an eccentric wheel, can be amplified in the band response between the guides.

The transport velocity (c) has been restricted to a constant in most studies. Miranker [52] introduced variable velocity in his analysis but did not develop solutions for these cases. Transverse excitation induced by a variable mass transport velocity in pipes transporting oil has been observed in experiments [50]. An approximate analysis indicating that acceleration of the transport mass is a stabilizing effect and its deceleration a destabilizing process has been presented [60]. The practical importance of the phenomenon to band saws appears minimal. The motion of a string under an accelerating force or mass has been discussed [32, 33, 82, 84].

Approximate, bounding natural frequency solutions have been published [62] for an axially moving wide band or plate -- probably a realistic model for large band saws. The undamped equation of motion is

$$D\nabla^4 w + 2mc\, w_{,xt} + (mc^2 - R(c,t))\, w_{,xx} + m\, w_{,tt} = 0 \qquad (3)$$

D is the flexural stiffness; ∇^4 is the biharmonic operator. Upper and lower bounds for the first natural frequency have been plotted against band velocity for wide bands in Figure 5. The related problem of an elastic plate subjected to moving forces has been discussed [2, 36, 48].

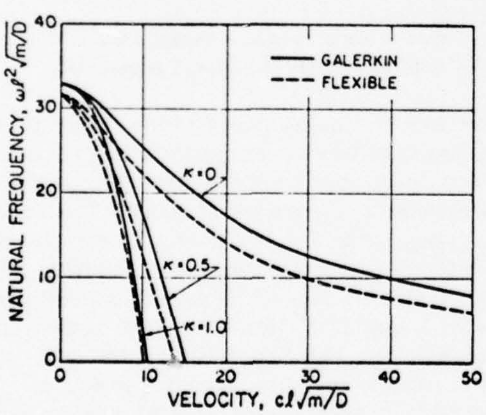


Figure 5. Theoretical Fundamental Frequency Bounds vs Band Velocity for a Wide Bandsaw ($\ell = 3b$, $R_0 = 100\, d/\ell$) [62]

The state of stress of the band saw blade is known to significantly affect vibration and stability [103]. Stress does mechanical work during deformation of the blade, alters transverse displacement of the saw under a given load, and, in effect, changes the blade stiffness. Initial stresses purposely introduced into the blade by rolling, hammering, or heating are known to significantly affect stability. Experiments have shown [43] that a stationary band, initially stressed by a longitudinal rolling operation, has a higher torsional fundamental frequency than an unstressed band; however, the fundamental frequency of transverse bending is unchanged. The effects of initial stressing on band saw vibration have not been thoroughly investigated. The subject awaits a formal investigation of an optimum initial stressing criterion and the band stability criterion.

Thermal effects during cutting alter the state of stress in the band [96, 103]. The effects of feed speed and axial velocity of the band on heat generation during cutting have been investigated [10, 86]. Sanev [86] used a semiconductor-type bolometer for non-contacting temperature measurements and reported typical gradients of approximately 30°C across the width (100 mm) of the blade just downstream from the workpiece. The stresses arising in band saw blades due to temperature gradients have been theoretically analyzed [87, 88]. The effects of thermal stresses on the band saw vibration problem have not been investigated.

BAND EXCITATION

The band saw can be excited as a result of complete cutting forces, interaction between the blade lateral surfaces and the workpiece, wheel eccentricities and irregularities, band stiffness variations, disturbances caused by the weld, and the guides. These excitations are either direct or parametric. During cutting direct periodic forces occur -- such as those at the tooth passage frequency -- as well as direct random forces -- such as those caused by interactions of blade surfaces with the workpiece. Direct forces drive the band in transverse-torsional motion. When sufficient direct excitation energy exists at forcing frequencies at or near the natural frequencies of the band saw, resonant amplification occurs and large amplitude band vibrations are produced.

The cutting force can be represented by its normal, tangential, and transverse components (see Fig. 2). Early investigations [37, 71, 94, 95] of cutting forces have been summarized [70]. More recent studies have been reported [1, 22, 23, 30, 31], and comprehensive theoretical and experimental investigations have been carried out [73-78]. Typical magnitudes of the cutting force components are presented in Table 2 [76, 77].

Table 2. Cutting Force in Band Saws [76, 77]

Cutting Force Component	Magnitude, N	
	Range	Typical
Tangential F_t	100-1,000	500
Normal F_n	0-600	250
Transverse F_b	0-25	15

The purely torsional response of an axially moving band was first investigated with a concentrated edge load [7]. The importance of coupled bending-torsion of band saws to the edge buckling load has been demonstrated [98]. The coupled bending-torsion vibration and buckling problems for general concentrated and distributed edge loading have been treated [56, 57]. These buckling and vibration problems have not been treated in sufficient depth, however, and lack experimental verification. Specific process and design parameters remain to be related to these excitation mechanisms. The interaction between band surfaces and the workpiece is also an important area for investigation but will be difficult to pursue.

Periodic variation of band saw tension can induce transverse instability when the variation in tension frequency is twice any natural frequency of the band saw, particularly the fundamental frequency of the band. This instability is termed parametric vibration because the band vibration is induced by an oscillating stiffness rather than by any direct driving of the band by external forces. Experimental investigations of parametric excitation support the theoretical developments [25, 68]; a wheel rotating at twice the fundamental frequency can be expected to cause transverse instability. This phenomenon has been discussed [59].

Parametric and direct excitation forces drive the band and are significant factors in predicting transverse motion of the band. It is surprising that more effort has not been aimed at developing analytical models that more completely describe the total excitation of the band. It may be that experiments for identifying loading mechanisms are too difficult.

Static, or divergence, instability occurs at an edge load and is dependent upon band geometry, material, supports, tension, and transport velocity. The trend toward higher speeds and thinner band saw blades has reduced the load at which edge buckling occurs. This reduction in buckling load (F_{ncr}) is approximately proportional to the square of the velocity (c^2) until instability occurs at virtually zero edge load at the critical band velocity (c_{cr}) [14, 53, 57, 67, 83]. A typical example of the dependence of edge buckling load on the band axial velocity is shown in Figure 6. The axial or transport velocity of the band cannot be neglected in predicting the buckling load [35, 79]; this has been shown in investigations for concentrated and distributed edge loads [57].

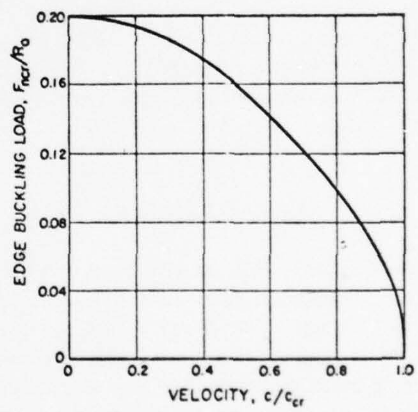


Figure 6. Edge Buckling Load -- Axial Velocity Relationship
(R_0 = 22.241 kN; b x h = 8.065 cm^2; ℓ = 1.524 m)
[57]

Noise generated by band saws is known to exceed 95 dBA [42, 104]. Noise mechanisms in circular saws have received some attention [64, 99], but there have been relatively few investigations of the sources of band saw noise [45, 72]. It has been concluded [72] that aerodynamic excitation by saw teeth does not contribute significantly to band saw noise; this result is in contrast with circular saw noise, in which aerodynamic excitation can be significant [18].

VIBRATION CONTROL

Achievement of effective vibration control will require establishment of the relationship between band excitation and instability mechanisms and design and operating parameters. Some techniques for vibration reduction and control are currently available, however. The oldest and most widely used is blade stress modification using initial stresses. In recent years initial stressing by thermal methods has also been used [24, 38, 80].

Vibration feedback control by on-line heating [61] and the use of active electromagnetic guides [28] has been demonstrated for circular saws. These applications seem to be directly applicable to band-saw vibration control as well. Automatic on-line adjustment of axial tension [69], feed rate [90], and guide position [77] have also been suggested and appear promising. Such novel guides as aerostatic guides [15, 77] and wide guides [85] are also being investigated as possible measures for vibration reduction and control.

CLOSING REMARKS

The effects of band axial velocity, band axial tension, parametric excitation, and normal edge loads on band saw vibration and stability have been investigated. These aspects of band saw vibration are similar to the vibration problems that arise in belts, pipes, and tapes. However, many fundamental questions regarding the effects of guides -- thermally induced and initial stresses, cutting forces, propagation of disturbances, and blade-workpiece lateral interactions -- which are important in band saw vibration, remain unanswered. Research in these areas to determine stability criteria and relate them to specific design and process parameters will be necessary before band saw design and the band sawing process can be optimized.

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LITERATURE REVIEW

survey and analysis of the Shock and Vibration literature

The monthly Literature Review, a subjective critique and summary of the literature, consists of two to four review articles each month, 3,000 to 4,000 words in length. The purpose of this section is to present a "digest" of literature over a period of three years. Planned by the Technical Editor, this section provides the DIGEST reader with up-to-date insights into current technology in more than 150 topic areas. Review articles include technical information from articles, reports, and unpublished proceedings. Each article also contains a minor tutorial of the technical area under discussion, a survey and evaluation of the new literature, and recommendations. Review articles are written by experts in the shock and vibration field.

Reviews of thermomechanical vibrations and transmission line vibrations are contained in this issue of the DIGEST. Professor Chung of the University of Alabama in Huntsville surveys dynamic problems in thermomechanics including problems in fiber composites. Professors Ramamurti, Sathikh, and Chari review the behavior of transmission lines, vibration dampers and bundle conductors.

THERMOMECHANICAL VIBRATIONS

T.J. Chung*

Abstract - This article surveys dynamic problems in thermomechanics. A special case has to do with nonlinear thermomechanical response in fiber composites. Linear and nonlinear vibration problems in thermomechanics are associated with elasticity, viscoelasticity, plasticity, and magnetoelasticity. The generalized thermoelasticity dealing with second sound is also discussed.

Mechanical work done by a solid body generates heat; conversely, heating a body produces mechanical work. The interconvertibility of mechanical work and heat energy was recognized in the 19th century by Joule and Kelvin. Dynamic mechanical loads and sudden heat deposition create difficult problems. Such problems occur in aeronautics and astronautics, nuclear reactors, high energy particle accelerators, and cyrogenics.

Thermomechanics consists of several categories, depending on the mechanical and thermal properties of the material, which may be elastic, viscoelastic, or plastic. Under thermal coupling the behavior of the various materials is described as thermoelasticity, thermoviscoelasticity, or thermoplasticity, respectively. If the material is subjected to magnetic fields, the phenomenon is described as magnetothermoelasticity. On the other hand, thermal properties are defined by characterization of heat flux. Most materials obey the linear Fourier law. Thermal conductivities are often temperature dependent, resulting in a nonlinear heat conduction equation. With such materials as dielectric solids the Fourier law is not valid because heat transport is governed by wave propagation rather than diffusion. This phenomenon, known as second sound, occurs in liquid helium. In addition to the complications attributable to material properties, thermomechanical behavior can also be coupled with second order effects of strain and with shock discontinuities.

BASIC EQUATIONS FOR THERMODYNAMICS OF SOLIDS

The foundation of the thermodynamics of solids has been presented [20, 29, 62]. Summaries of applications to thermomechanics are also available [6, 7, 10, 31]. Discussions of irreversible thermodynamic processes have been given [25, 28, 42, 53, 54].

The principal of conservation of energy states that the time rate of change of kinetic energy K plus internal energy U is equal to the rate of work done on the system F plus the changes of all other energies of the system per unit time E_α

$$\dot{K} + \dot{U} = F + \sum_{\alpha} E_\alpha \tag{1}$$

The superposed dot implies a time rate; E_α represents heat energy. If only heat energy Q is considered,

$$\dot{K} + \dot{U} = F + Q \tag{2}$$

This is the first law of thermodynamics. Because this equation pertains to a finite volume of material, it is often called a global form of the first law. Under sufficient conditions of smoothness, the Green-Gauss theorem can be used to derive a local form of the first law that represents the energy balance at a point in a continuum.

$$\int_\Omega \left[(\sigma^{ij}_{\ |i} + \rho F^j - \rho a^j)\, v_j - (\rho\dot{\epsilon} - \sigma^{ij} v_{j|i} - q^j_{\ |j} - \rho r) \right] d\Omega = 0 \tag{3}$$

or

$$\sigma^{ij}_{\ |i} + \rho F^j - \rho a^j = 0 \tag{4}$$

$$\rho\dot{\epsilon} = \sigma^{ij}\dot{\gamma}_{ij} + q^j_{\ |j} + \rho r \tag{5}$$

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where σ^{ij} is the Cauchy stress tensor, ρ is the mass density, F^i is the body force, a^j is the acceleration, v_j is the velocity, ϵ is the internal energy density, γ_{ij} is the strain tensor, q^j is the heat flux, and r is the heat supply. The vertical stroke indicates covariant differentiation, and subscripts and superscripts denote covariant and contravariant components of a tensor, respectively.

Consider the absolute temperature θ and the entropy η as fundamental properties of all thermodynamic systems. The second law of thermodynamics is characterized by the Clausius-Duhem inequality: the total entropy production is always greater than, or equal to, zero.

$$\rho\theta\dot{\eta} \geqslant q^i_{|i} - \frac{1}{\theta} q^i\theta_{,i} + \rho r \tag{6}$$

The comma denotes the partial derivative. Introducing the specific free energy

$$\psi = \epsilon - \eta\theta \tag{7}$$

and defining internal dissipation D as

$$D = \sigma^{ij}\dot{\gamma}_{ij} - \rho(\dot{\psi} + \eta\dot{\theta}) \tag{8}$$

leads to derivation of the inequalities.

$$\frac{1}{\theta} q^i\theta_{,i} + D \geqslant 0 \tag{9}$$

$$D = \rho\theta\dot{\eta} - q^i_{|i} - \rho r \geqslant 0 \tag{10}$$

A thermodynamic process is defined as a set of functions, including the motion $z_i(\underset{\sim}{x}, t)$ and the fields $\theta(\underset{\sim}{x}, t)$, $\sigma^{ij}(\underset{\sim}{x}, t)$, $q^i(\underset{\sim}{x}, t)$, and $\eta(\underset{\sim}{x}, t)$. These functions are defined at $\underset{\sim}{x}$ at time t, provided they satisfy the principles of linear and angular momentum and conservation of energy for every part of the body. The usual classification of thermodynamic processes is isothermal, adiabatic, isentropic, or isoenergetic, respectively, if $\dot{\theta}$, Q, $\dot{\eta}$, or $\dot{U}$ are zero.

It should be noted that the equations are completely general; no restrictions have been imposed as to the magnitudes of strains or material properties. Thermomechanical vibrations, the subject of this paper, are governed by all of these equations. Constitutive equations are specified for the material under study. These specialized cases are discussed in the following sections.

THERMOELASTIC VIBRATIONS

The constitutive equations for linear thermoelastic behavior begin with the free energy

$$\rho\psi = \frac{1}{2} E_{ijk\ell}\gamma_{ij}\gamma_{k\ell} - \beta_{ij}T\gamma_{ij} - \frac{1}{2}\frac{c}{T_o} T^2 \tag{11}$$

from which

$$\sigma_{ij} = \rho\frac{\partial\psi}{\partial\gamma_{ij}} = E_{ijk\ell}\gamma_{k\ell} - \beta_{ij}T \tag{12}$$

$$\rho\eta = -\rho\frac{\partial\psi}{\partial T} = \frac{1}{T_o} cT + \beta_{ij}\gamma_{ij} \tag{13}$$

$E_{ijk\ell}$ is the tensor of elastic moduli, β_{ij} is the thermoelastic constants, T and T_o are the temperature change and reference temperature respectively, and c is the specific heat. Note that σ_{ij} is the covariant component of the stress tensor; this implies that stress is defined on the undeformed state as is customary for the infinitesimal theory. The Fourier law is given by

$$q_i = \kappa_{ij}T_{,j} \tag{14}$$

The heat flux q_i is also defined in undeformed state, and κ_{ij} is the coefficient of thermal conductivity. For the Hookean isotropic material with zero internal dissipation, the equations of motion and heat conduction assume the following forms

$$\begin{aligned}&\mu u_{i,jj} + (\lambda + \mu) u_{j,ji} + \rho F_i \\ &\quad - (3\lambda + 2\mu)\alpha T_{,i} - \rho\ddot{u}_i = 0\end{aligned} \tag{15}$$

$$c\dot{T} + T_o\alpha(3\lambda + 2\mu)\dot{u}_{i,i} - \kappa T_{,ii} + \rho r = 0 \tag{16}$$

where α is the coefficient of thermal expansion.

Analytical solutions of equations (15) and (16) have been thoroughly investigated. Plane harmonic waves in an infinite thermoelastic medium have been studied [15, 16]. Waves in half-space have been generalized to the case of an elastic layer [59]. Spherical waves can occur in an infinite medium containing a spherical cavity if the cavity surface is subjected to heating, mechanical loading, or deformation uniformly distributed over the surface [46]. For the case of cylindrical waves in finite thermoelastic space, the displacements and stresses depend only on radius and time [46]. The propagation of Rayleigh surface waves in thermoelastic media was first studied in 1958 [38]. Chadwick and Windle [17] subsequently analyzed the roots of the complex equation to determine the phase velocity of Rayleigh waves.

Thermoelastic waves produced by sources varying non-periodically in time are much more complicated than harmonic waves. Laplace and Fourier transforms can be used to solve equations (15) and (16). A number of dynamic problems of thermoelasticity have been solved [27 32, 33, 59]. The sudden application of heat to a plane bounding the thermoelastic half-space causes a plane thermoelastic wave to propagate in the longitudinal axis. Known as the Danilovskaya problem [24] it has been investigated [9].

Under most general types of loadings, boundary conditions, and geometries the analytical solutions are intractable. Thus, variational methods are important for approximate analytical solutions [13, 44, 56]. Finite element methods are more general.

Dynamically coupled thermoelasticity problems have been presented using finite element methods [47, 48]. They have also been applied to inelastic materials with or without memory and irregular boundary conditions and geometries.

THERMOVISCOELASTIC VIBRATIONS

In thermoviscoelasticity a simple form of free energy such as equation (11) is not valid. Consider a class of thermomechanically simple materials; that is, materials whose reponse at a particle ζ at time t depends upon the histories of the deformation and the temperature at ζ. Such materials may be characterized by a collection of constitutive equations for the free energy ψ, the stress tensor σ^{ij}, the specific entropy η, and the heat flux vector q^i of the form

$$\psi = \overset{\infty}{\underset{s=0}{\hat{\psi}}} [\gamma_r(t), \theta_r(t); \gamma, \theta, g] \tag{17a}$$

$$\sigma^{ij} = \overset{\infty}{\underset{s=0}{\hat{\sigma}}}{}^{ij} [\gamma_r(t), \theta_r(t); \gamma, \theta, g] \tag{17b}$$

$$\eta = \overset{\infty}{\underset{s=0}{\hat{\eta}}} [\gamma_r(t), \theta_r(t); \gamma, \theta, g] \tag{17c}$$

$$q^i = \overset{\infty}{\underset{s=0}{\hat{q}}}{}^i [\gamma_r(t), \theta_r(t); \gamma, \theta, g] \tag{17d}$$

Here $\overset{\infty}{\underset{s=0}{\hat{\psi}}}$ ... $\overset{\infty}{\underset{s=0}{\hat{q}}}{}^i$ are functionals of the past histories. The functions $\gamma_r(t)$, $\theta_r(t)$ denote the restrictions of $\gamma(s)$ and $\theta(s)$ to the open intervals $s \epsilon (0, \infty)$; they are functions of the current values $\gamma = \gamma(0)$, $\theta = \theta(0)$, and $g = \text{grad}\ \theta$. Specific choices of the functions in equations (17) are discussed below.

The problem of thermoviscoelasticity has been studied [8, 20, 60]. The governing equations depend upon the way in which the constitutive equations are constructed. One is a phenomenological model [60], another is the theory of irreversible thermodynamics [8], and a third involves state variables in terms of a topological space [20]. The three approaches, although different in concept, lead to similar results for thermorheologically simple materials [21]. Biot's theory [8] was used to study the thermoviscoelastic behavior of solids under cyclic loading [57, 58]. Coleman's theory [20] was used to solve a thermorheologically simple circular rod subjected to torsional vibration [22]. Schapery's approach [57, 58] was used to study the problem of finite wave propagation in a nonlinearly thermoviscoelastic thin rod subjected to mechanical or thermal time-dependent loading [1]. Oden and Armstrong [49] presented the finite element solution of a class of nonlinear problems in thermoviscoelastic thick-walled hollow cylinder subjected to time-varying internal and external pressures, temperatures, and heat fluxes. In this study the free energy functional [21] corresponded to equation (17).

$$\rho\psi = \psi_0 + \int_0^{\xi} D_{ij}(\xi - \xi') \frac{\partial \gamma_{ij}}{\partial \xi'} d\xi' - \int_0^{\xi} f(\xi - \xi') \frac{\partial \theta}{\partial \xi'} d\xi'$$

$$+ 1/6\, \delta_{ij}\delta_{mn} \int_0^{\xi}\int_0^{\xi} [3K(\xi-\xi', \xi-\xi'') - 2G(\xi-\xi', \xi-\xi'')] \frac{\partial \gamma_{ij}}{\partial \xi'} \frac{\partial \gamma_{mn}}{\partial \xi''} d\xi' d\xi'' + 1/4(\delta_{ij}\delta_{mn} + \delta_{in}\delta_{jm}) \int_0^{\xi}\int_0^{\xi} 2G(\xi - \xi', \xi - \xi'') \frac{\partial \gamma_{ij}}{\partial \xi'} \frac{\partial \gamma_{mn}}{\partial \xi''} d\xi' d\xi''$$

$$-\delta_{ij} \int_0^{\xi} \int_0^{\xi} 3\alpha K(\xi - \xi', \xi - \xi'') \frac{\partial \gamma_{ij}}{\partial \xi'} \frac{\partial \theta}{\partial \xi''} d\xi' d\xi''$$

$$- 1/2 \int_0^{\xi} \int_0^{\xi} m(\xi - \xi', \xi - \xi'') \frac{\partial \theta}{\partial \xi'} \frac{\partial \theta}{\partial \xi''} d\xi' d\xi'' \quad (18)$$

where ξ is the reduced time; ψ_0 is the constant, D_{ij}; and f, K, G, and m are material kernals. The standard procedure is used to derive expressions for a stress tensor, entropy, and a dissipation function.

For materials with viscoelastic behavior characterized by general Maxwell models the incremental free energy has been used [18, 19].

$$\rho\psi = 1/2\, E_{ijk\ell}\gamma_{ij}\gamma_{k\ell} - \beta^{ij}\, T\, \gamma_{ij} - \frac{c}{2T_0} T^2$$

$$- \sum_{r=1}^{m} \underset{(r)}{\beta^{ij}}\, T \alpha_{ij}^{(r)} + 1/2 \sum_{r=1}^{m} \underset{(r)}{\xi^{ijk\ell}}\, \alpha_{ij}^{(r)} \alpha_{k\ell}^{(r)} \quad (19)$$

$$+ \sum_{r=1}^{m} \underset{(r)}{\xi^{ijk\ell}}\, \alpha_{ij}^{(r)}\, \gamma_{k\ell}$$

where $\underset{(r)}{\xi}^{ijk\ell}_{(r)}$ is the tensor of viscoelastic moduli, and α_{ij} is the internal state variable

$$\alpha_{ij}^{(r)} = \int_0^t \exp \left[\frac{-(t - \tau)}{T_{(r)}}\right] \frac{\partial \gamma_{ij}}{\partial \tau} d\tau \quad (20)$$

$T_{(r)}$ is the relaxation time. Such a formulation provides the following constitutive equations for stress, entropy, and internal dissipation

$$\sigma^{ij} = E_{ijk\ell}\gamma_{k\ell} - \beta^{ij}T + \sum_{r=1}^{m} \underset{(r)}{\xi^{ijk\ell}}\, \alpha_{k\ell}^{(r)} \quad (21a)$$

$$\rho\eta = \beta^{ij}\gamma_{ij} + \frac{cT}{T_o} + \sum_{r=1}^{m} \underset{(r)}{\beta^{ij}}\, \alpha_{ij}^{(r)} \quad (21b)$$

$$D = \sum_{r=1}^{m} (\underset{(r)}{\beta^{ij}}\, T\dot{\alpha}_{ij}^{(r)} - \underset{(r)}{\xi^{ijk\ell}}\, \alpha_{k\ell}\, \dot{\alpha}_{ij}^{(r)}$$

$$- \underset{(r)}{\xi^{ijk\ell}}\, \gamma_{k\ell}\, \dot{\alpha}_{ij}^{(r)}) \quad (21c)$$

Thus the governing equations (15) and (16) may be replaced by

$$\mu u_{i,jj} + (\lambda + \mu) u_{j,ji} + \rho F_i - (3\alpha + 2\mu) \alpha T_{,i}$$

$$+ \sum \underset{(r)}{\xi^{ijk\ell}}\, \alpha_{k\ell,j}^{(r)} - \rho \ddot{u}_i = 0 \quad (22)$$

$$c\dot{T} + T_o\alpha(3\lambda + 2\mu)\, \dot{u}_{i,i} + T_o \sum_{r=1}^{m} \beta^{(r)} \dot{\alpha}_{ii}^{(r)}$$

$$- \kappa T_{,ii} - \rho r - D = 0 \quad (23)$$

Solutions of equations (22) and (23) using finite elements and stability and convergence have been discussed [19].

THERMOELASTOVISCOPLASTICITY

A nonlinear structural system that exhibits elastic-viscoelasticplastic behavior under a combination of impulsive mechanical and thermal loadings has been investigated. Dillon [26] experimented with coupled thermoplasticity; no viscous effect was included. The motion of the yield surface at elevated temperatures under pre-stress has also been investigated [51]. Experiments led to the proposal of a hardening law; no dynamic or viscous effects were considered.

An analytical framework for elastic and plastic materials in which internal state variables were related to the dislocation motion has been reported [36]. The internal state variable approach has also been explored by Rice [55], who proposed constitutive relations at finite strain.

Coupled thermoelastoplasticity has been studied using the Il'yushin plasticity function [23, 52]. A more practical formulation involves derivation of the conditions for propagating three-dimensional acceleration and strong discontinuity (shock) waves, as well as amplitude attenuation in thermoelastic viscoplastic materials [37]. The results show that the velocities of propagation in these materials are the same as those in a thermoelastic material. Moreover, only one longitudinal wave propagates for Fourier's law. The entropy on the front of this wave is discontinuous, but the temperature is not. The rate of decay of amplitude depends on thermoconductivity but is independent of energy dissipation. For the Maxwell-Cattaneo relation, however, two longitudinal waves exist; all dependent variables including temperature are discontinuous on their fronts. The attenuation of the amplitude is stronger than for

Fourier's law and also depends on plastic energy dissipation.

In an attempt to include viscoplastic effects Perzyna and Wojno [50] developed a thermodynamic theory of viscoplasticity. They introduced a second order tensor, called the inelastic tensor, which played the role of a hidden state variable. A unified approach for thermoviscoplasticity of crystalline solids in which dislocation behavior is considered has been examined [ ].

Chung [18] formulated a problem of thermoelasto-viscoplasticity using incremental free energy. He used the finite element method to solve equations (22) and (23) for a composite cylinder subjected to combined impulsive mechanical and thermal loadings. Of particular interest was the calculation of internal dissipation as a function of time.

MAGNETOTHERMOELASTICITY

Magnetothermoelasticity represents the interaction between strain and electromagnetic fields in problems of geophysics, optics, and acoustics. It is known that strain rate effects appear in the electrodynamics equations of slowly moving bodies, whereas the derivatives of the Maxwell electromagnetic pressures (Lorentz forces) appear in the equations of motion. Some contributions in magnetothermoelasticity have been made [14, 36].

The linearized basic governing equations for magnetothermoelasticity in an anisotropic body are

$$\text{rot}\,\underset{\sim}{h} = \frac{4\pi}{c_m}\underset{\sim}{j} + \frac{1}{c_m}\dot{\underset{\sim}{D}}, \quad \text{rot}\,\underset{\sim}{E} = -\frac{1}{c_m}\dot{\underset{\sim}{b}} \qquad (24a, b)$$

$$\text{div}\,\underset{\sim}{b} = 0, \quad \text{div}\,\underset{\sim}{D} = 4\pi\rho_e \qquad (24c, d)$$

$$\rho\ddot{u}_i = \sigma_{ik,k} + \frac{1}{c_m}(\underset{\sim}{j} \times \underset{\sim}{B_o})_i + \rho_e E_i + P_i \qquad (25)$$

$$c\dot{T} + T_o\beta_{ik}\dot{u}_{i,k} - (\kappa_{ik}T_{,k})_i + (\pi_{ik}\underset{\sim}{j_k})_{,i} = f \qquad (26)$$

where

$$b_i = \mu_{ik}h_k,\ D_i = \epsilon_{ik}[E_k + \frac{1}{c_m}(\dot{\underset{\sim}{u}} \times \underset{\sim}{B_o})_k] - \frac{1}{c_m}(\dot{\underset{\sim}{u}} \times \underset{\sim}{H_o})_i$$

$$\sigma_{ik} = E_{ikmn}\gamma_{mn} - \beta_{ik}T - \int_0^t R_{ikmn}(t-\tau)\,[\gamma_{mn}(\tau) - \beta_{mn}T(\tau)]\,d\tau$$

$$\underset{\sim}{j_i} = \eta_{ik}E_k - \lambda_{ik}T_{,k} + \frac{\eta_{ik}}{c_m}(\dot{\underset{\sim}{u}} \times \underset{\sim}{B_o})_k + \rho_e\dot{u}_i$$

The quantities $\underset{\sim}{H_o}$ and $\underset{\sim}{B_o}$ are concerned with the constants and the primary magnetic field. The quantities $\underset{\sim}{j}$, $\underset{\sim}{E}$, $\underset{\sim}{D}$, $\underset{\sim}{h}$, $\underset{\sim}{b}$, and $\underset{\sim}{u}$ are the linear disturbed fields. The function f denotes the density of external and internal heat sources. The functions R_{ikmn} are relaxation functions for mechanical stress in a Boltzmann solid. The coefficients μ_{ik} and ϵ_{ik} denote the tensor of magnetic and electric permeability of the body, respectively; η_{ik} is the tensor of electric conductivity; π_{ik} is a tensor determining the influence of the density of the current vector on the density of heat flow; and λ_{ik} is a tensor relating temperature gradient to electric current.

Solution of equations (24), (25), and (26) is a formidable task. Finite element formulation appears to be the most logical approach. Some work related to magnetohydrodynamics has been undertaken [11, 12, 61, 63]. A complete solution for magnetothermoelasticity using finite elements has not yet appeared in the literature.

Approximate analytical solutions have been obtained using Laplace transforms; for example, the case of the elastic half-space with finite conductivity [34]. Certain electromagnetic discontinuity waves were propagated in the medium at the velocity of light; in additon, discontinuity waves were propagated at near-sonic velocities. When the displacement current in the conducting medium was neglected, the discontinuity waves propagated at the velocity of light became diffusional, expressing the infinite propagation velocity of perturbations. This behavior occurs because the magnetothermoelastic field equations change from a hyperbolic to a parabolic system.

SECOND SOUND

It is known that second sound (thermal waves) occur in solids despite the limited frequency range of thermal excitation, or frequency window [3, 4].

The free energy ψ depends not only on the temperature and temperature gradient but also on history of the temperature gradient. The Fourier law should be modified to

$$q_i + \tau \dot{q}_i = - \kappa \frac{\partial T}{\partial X_i} \tag{27}$$

where τ is the relaxation time. This work has provided impetus for reformulating the heat conduction equation from a classical parabolic type to a hyperbolic one. The reformulation eliminates the paradox of an infinite velocity of propagation, which is inherent in the existing coupled theory of thermoelasticity.

Using the definitions in equations (12) and (13) together with (27), it can be shown that, for an isotropic material,

$$\begin{aligned} \kappa T_{,ii} = & - \rho T [\frac{\partial^2 \psi}{\partial T^2} (\dot{T} + \tau \ddot{T}) + \frac{\partial^2 \psi}{\partial \gamma_{ij} \partial T} (\dot{\gamma}_{ij} + \tau \ddot{\gamma}_{ij})] \\ & - \rho \tau [\dot{T}^2 (\frac{\partial^2 \psi}{\partial T^2} + T \frac{\partial^3 \psi}{\partial T^3}) + \dot{\gamma}_{ij} T (\frac{\partial^2 \psi}{\partial \gamma_{ij} \partial T} + 2T \frac{\partial^3 \psi}{\partial \gamma_{ij} \partial T^2}) \\ & + \dot{\gamma}_{ij}{}^2 (T \frac{\partial^3 \psi}{\partial^2 \gamma_{ij} \partial T})] \end{aligned} \tag{28}$$

or, for linearized theory,

$$\kappa T_{,ii} = - T [\frac{\partial^2 \psi}{\partial T^2} (\dot{T} + \tau \ddot{T}) + \frac{\partial^2 \psi}{\partial \gamma_{ij} \partial T} (\dot{\gamma}_{ij} + \tau \ddot{\gamma}_{ij})] \tag{29}$$

Consistent with usual linear theory of thermoelasticity, the expression in equation (29) can be reduced to

$$\kappa T_{,ii} = c(\dot{T} + \tau \ddot{T}) + \alpha T_o (3\lambda + 2\mu)(\dot{\gamma}_{ii} + \tau \ddot{\gamma}_{ii}) \tag{30}$$

The system of equations (15) and (30) can now be called a generalized dynamic theory of thermoelasticity.

A quiescent, isotropic, thermoelastic half-space at a uniform temperature and with the free surface (x=0) subjected to a step-strain has been considered [40]. A strain wave is propagated in the x-direction because of the mechanical disturbance. This sudden change in strain affects the temperature field, and thermal disturbances are propagated in the medium. These two disturbances are related according to the governing equations (15) and (30). Results indicate that the coupling between temperature and strain becomes negligible at temperatures near absolute zero and that the relaxation constant becomes small and generalized at high temperatures. The coupling coincides with conventional theory as temperature increases.

Additional studies on second sound have been reported [2, 43]. It has been shown that explicit expressions can be obtained for various quantities that characterize the thermal coupling on plane harmonic thermoelastic waves in unbounded media, as well as Rayleigh's surface waves propagating along the free surface of a half-space [43]. Relevant results of previous investigations [16, 39] were obtained as special cases.

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TRANSMISSION LINE VIBRATIONS

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Abstract - This article briefly reviews the general behavior of transmission lines, vibration dampers, bundle conductors, and spacers.

The need for power transmission at high and ultra-high voltages is of international importance. Of the various electrical and mechanical problems associated with such transmission, the major challenges are vibration and such related problems as galloping, aeolian vibrations, and subspan oscillations. Their relative importance depends on local geographical and weather conditions.

Three excellent surveys [1-3] summarized work to 1974. The practical engineering aspects of subspan oscillations and the more theoretical research problems have also been dealt with [1]. The general nature of wind-induced vibration of bundle conductors and their practical solutions have also been reviewed [2, 3]. General coupled extensional torsional behavior of wire rope has been considered [4]. Dynamic properties of wire ropes have been presented [5-8] as have contact stresses of twisted wires [9]. The general behavior of an overhead transmission line has also been discussed [10].

Measurement of the vibrations of overhead transmission lines in the U.S.S.R. has been described [11]. Measuring methods and apparatus used to test susceptibility are included. Experimental and simulation studies of transmission line vibrations in Australia have been discussed [14]. A procedure for calculating wind forces based on a statistical approach has been published [15]. The phenomenon of vortex shedding behind vibrating cylinders has also been described [16] as have conductor galloping [17] and wind tunnel studies on the behavior of conductors [18, 19]. Aeolian vibrations have been estimated [20, 21]. Precise determinations of the in-plane oscillations of a flexible line have been made [22]. Practical solutions to transmission line vibration problems have been given [23].

VIBRATION DAMPERS

The merits of a comprehensive computer program that permits near-optimum damper utilization have been discussed [24]. An experimental investigation concerning the way in which retroactive installation of dampers minimizes conductor damage has been reported [25], as has experimental work on a long crossing span fitted with dampers [26]. Methods for determining damper effectiveness have been discussed [27-30], as have damper selection and manufacturing methods [31]. An exhaustive computer program dealing with the transmission line response, optimization of dampers, and determination of maximum span length has been developed [32]. A vibration test system tailored to laboratory applications has been reported [33]. Adami and Ykema [34] discussed damping aeolian vibrations with auxiliary mass dampers [34]. A variation of the original Stockbridge damper has been developed [35].

BUNDLE CONDUCTORS AND SPACERS

Case histories in which conductor galloping became a problem when bundling was used in transmission lines have been cited [36]. The transfer matrix has been used to analyze conductor bundles [37]. Experiments in Italy have been compared with mathematical studies [38, 39]. A more fundamental study was concerned with the vibrations induced in two cylinders, one of which is in the wake of the other [40, 41]. Another similar study has also been reported [42]. Possible ways for reducing the noise on transmission lines has been investigated by analyzing individual subconductors [43]. The problem of thermal shrinkage in rubber bushes of spacer dampers has been discussed [44]. Work has been done on the effects of different conductor bundles on spacer performance [45, 46]. A qualitative guide to spacers has been published [47]. Both experimental and analytical work on aerodynamically-

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induced oscillations of bundle conductors have been reported [48]. Experimental work on bundled conductors at the Hydro Quebec Research Institute has been reported [49, 50]. A structural and mechanical test program has been proposed for a Moro UHV mechanical test line consisting of single and bundled conductors [51]. Linearized equations of motion have been used to determine the boundaries of instability for wake-induced oscillations of bundle conductors [52]. Data on bundle conductor galloping in Japan have been compiled [53]. Guidelines on the relationship between conductor tension and protectable span length and armor rods and dampers, as well as the efficiency of various available dampers are available [54-57]. Extensive tests for determining the torsional behavior of two- and four-conductor bundles with various subspan arrangements provides data necessary to develop galloping control [58].

Few papers on the application of the finite element method to transmission lines are available. The method has been applied to the vibration analysis of multi-conductor transmission lines [59], as well as those connected with the response of cables [60, 61]. The finite element method has recently been used to predict the nonlinear behavior of a bundle conductor [62, 63]. The time required was modest, and the method is suitable for qualitative evaluation of optimal bundle configurations.

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BOOK REVIEWS

THERMODYNAMIC EFFECTS IN WAVE PROPAGATION

P. Chen

This short book -- 32 pages -- contains one of the short courses on mechanics offered in Udine, Italy, in 1971. The book is divided into three sections. The basic equations for one-dimensional acceleration waves and shock waves are presented in Section 1. An equation that governs the amplitude of a shock wave is derived. A similar equation is derived for the amplitude of an acceleration wave. The assumption of the constitutive relation is not required in either equation.

In Section 2 the results obtained in Section 1 are applied to acceleration waves in elastic solids in which stress and temperature are determined from internal energy. The effects of heat conduction are ignored. The equation governing the amplitude of an acceleration wave reduces to the Bernoulli equation, which determines the growth or decay of an acceleration wave. General properties of the solutions to the Bernoulli equation are discussed in detail.

Shock waves in elastic solids are analyzed in Section 3. Stress and temperature are again assumed to be derivable from internal energy. The growth or decay of a shock amplitude depends on the difference between a quantity defined as λ and the strain gradient behind the shock. If the region ahead of the shock is at rest, λ vanishes and the growth or decay of a shock depends on the sign of the strain gradient behind the shock.

As in most books, misprints are unavoidable. Some of the misprints are trivial and can be easily identified. Others, such as quotations of equation numbers used to derive an equation, are difficult to detect. Nevertheless, the book is well written. The presentation is concise and clear. A list of references is provided at the end for those who want to pursue the subject further.

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APPLICATION OF METHODS OF THEORY OF PROBABILITY AND THEORY OF RELIABILITY TO ANALYSIS OF STRUCTURES

V.V. Bolotin
AD 776115
(Translated from Russian)

The application of probability theory and statistical dynamics to the calculation of static and dynamic loads in structures has assumed ever-increasing importance in recent years. This book is a continuation of an earlier study by the author (Statistical Methods in Structural Mechanics). The new volume extends the application of the theory of random fields. Calculation of the probability that a particular structure will work in a reliable fashion for a certain period of time remains the prime objective for effectively measuring its reliability.

The book contains three chapters. Chapter I considers the basic concepts of statistical dynamics and applies them to simple structures. Normal distribution, joint probability, and Rayleigh distribution are briefly discussed. The author considers Green's function applied to random theory, statistical dynamics in nonlinear systems, method of statistical linearization, theory of Markovian processes and application to statistical dynamics problems. Green's function is applied to stochastic boundary problems and nonlinear stochastic boundary problems.

Chapter II is concerned mainly with structural problems applied to elastic foundations (random in nature) and thermal stress problems. The author describes random characteristics of beams on elastic supports, thin elastic shells with random imperfections, and tension in plates with initial singularities. The chapter concludes with a discussion of random thermoelastic stresses in shells plus thermoelastic boundary effects, a most interesting topic.

Chapter III considers the application of the theory of reliability to structures and draws upon basic reliability concepts. A general theory of reliability is accompanied by examples. The author considers zero mean crossings, average number of maximum per unit time which are basis of random fatigue. The theory of extreme value is mentioned, as is multi-dimensional space, reliability, and the life of Markovian processes. Examples are used to illustrate the reliability of distributed systems.

The book is short and well written. The book is sometimes difficult to follow because the text relies on the previous volume. The reviewer would like to see this book combined with a revised edition of the previous volume. The discussion on random fatigue should be updated. The reviewer had difficulty in reading certain portions of this book because the pages were illegible. The many references should have been translated into English for the benefit of non-Russian readers. Nevertheless, the reviewer does recommend this book to those concerned with reliability of and random processes in structures.

Herb Saunders
General Electric Company - LSTGD
Building 41, Room 319
Schenectady, NY 12345

DYNAMIC ANALYSIS OF PRESSURE VESSEL AND PIPING COMPONENTS

C. Syndararajan
ASME, New York, 1977, $16.00

This monograph contains six papers presented at the Energy Technology Conference held in Houston, Texas, in September 1977. The purpose of this conference was to provide opportunities for stimulating interactions and cross fertilization among engineers using structural mechanics theories aided by computer numerical methods in pressure vessel and piping systems subjected to dynamic loads.

In general, the papers are well written and understandable to engineers in the field of interest. The technical treatments are plausible, and some analytical results were verified with experimental data. The reviewer believes that this book possesses a fine technical quality.

P.S. Chopra
Argonne National Laboratory
9700 S. Cass Avenue
Argonne, IL 60439

SHORT COURSES

NOVEMBER

DIGITAL SIGNAL PROCESSING

Dates: November 6-10, 1978

Place: The George Washington University Washington, D.C.

Objective: The course is designed for engineers, scientists, technical managers, and others who desire a better understanding of the theory and applications of digital signal processing. The objective of this course is to provide the participants with the essentials of the design of IIR and FIR digital filters, signal detection and estimation techniques, and the development of Fast Fourier Transform Algorithms. The applications of digital signal processing to speech processing will also be discussed. The mathematical concepts needed for understanding this course will be developed during the presentation.

Contact: Continuing Engineering Education Program, George Washington University, Washington, D.C. 20052 - (202) 676-6106 or toll free (800) 424-9773.

VIBRATION AND SHOCK TESTING

Dates: November 6-10, 1978

Place: Washington, D.C.

Objective: Lectures are combined with physical demonstrations: how structures behave when mechanically excited, how input and response forces and motions are sensed by pickups, how these electrical signals are read out and evaluated, also how measurement systems are calibrated. The relative merits of various types of shakers and shock machines are considered. Controls for sinusoidal and random vibration tests are discussed.

Contact: Wayne Tustin, Tustin Institute of Tech., Inc., 22 East Los Olivos St., Santa Barbara, CA 93105 - (805) 963-1124.

VIBRATION AND SHOCK SURVIVABILITY

Dates: November 6-10, 1978

Place: Ling Electronics, Anaheim, California

Objective: Topics to be covered are resonance and fragility phenomena, and environmental vibration and shock measurement and analysis, also vibration and shock environmental testing to prove survivability. This course will concentrate upon equipments and techniques, rather than upon mathematics and theory.

Contact: Wayne Tustin, 22 E. Los Olivos St., Santa Barbara, CA 93105 - (805) 963-1124.

16TH ANNUAL RELIABILITY ENGINEERING AND MANAGEMENT INSTITUTE

Dates: November 6-10, 1978

Place: Tuscon, Arizona

Objective: The course will cover the following topics: Reliability engineering theory and practice; Mechanical reliability prediction; Reliability testing and demonstration; Maintainability engineering, Product liability; and Reliability and Maintainability Management.

Contact: Dr. Dimitri Kececioglu, Aerospace and Mechanical Engineering Dept., University of Arizona, Bldg. 16, Tuscon, AZ 85721 - (602) 626-2495/626-3901/626-3054.

MACHINERY VIBRATIONS COURSE

Dates: November 13-16, 1978

Place: Oak Brook, Illinois

Objective: This course on machinery vibrations will cover physical/mathematical descriptions, calculations, modeling, measuring, and analysis. Machinery vibrations control techniques, balancing, isolation, and damping, will be discussed. Techniques for machine fault diagnosis and correction will be reviewed along with examples and case histories. Torsional vibration measurement and calculation will be covered.

Contact: Dr. Ronald L. Eshleman, Vibration Institute, Suite 206, 101 W. 55th St., Clarendon Hills, IL 60514 - (312) 654-2254.

DECEMBER

MACHINE PROTECTION AND MALFUNCTION DIAGNOSIS

Dates: December 11-15, 1978
Place: Carson City, Nevada
Objective: Topics to be covered include: Measuring and monitoring parameters for predictive maintenance; Eddy current probe and proximitor theory of operation; Installation procedures and common pitfalls; Permanent machine monitoring systems; System calibration procedures; Thrust position measurements; Troubleshooting the system; Transducer polarity rules; Hazardous area considerations; Introduction to machine data acquisition; Oscilloscope theory and operation; Oscilloscope cameras; Tunable filters, Vector filter-phase meter; Tape recorders; Keyphasor theory; and Electrical runout.

Contact: Training Manager, Bently Nevada Corporation, P.O. Box 157, Minden, Nevada 89423 - (702) 782-3611.

1979

JANUARY

STRUCTURED PROGRAMMING AND SOFTWARE ENGINEERING

Dates: January 8-12, 1979
Place: The George Washington University
Objective: This course provides up-to-date technical knowledge of logical expression, analysis, and invention for performing and managing software architecture, design, and production. Presentations will cover principles and applications in structures programming and software engineering, including stepwise refinement, program correctness, and top-down system development.

Contact: Continuing Engineering Education Program, George Washington University, Washington, D.C. 20052 - (202) 676-6106 or toll free (800) 424-9773.

FEBRUARY

VIBRATION AND LOOSE PARTS MONITORING SYSTEMS AND TECHNOLOGY

Dates: February 5-8, 1979
Place: Los Angeles, California
Objective: A course designed for users, utility designers specifying systems, installers, operators, and analysts of Vibration and Loose Parts Monitoring Systems. Classroom instruction in theory, installation, calibration, alarms and location, signature analysis, noise analysis, and troubleshooting and servicing. Practical demonstration includes student "hands-on" operation of equipment.

Contact: C.A. Parker, Nuclear Training Center, Atomics International, P.O. Box 309, Canoga Park, CA 91304 - (213) 341-1000, Ext. 2811.

FLOW-INDUCED VIBRATION PROBLEMS AND THEIR SOLUTIONS IN PRACTICAL APPLICATIONS: TURBOMACHINERY, HEAT EXCHANGERS AND NUCLEAR REACTORS

Dates: February 12-16, 1979
Place: The University of Tennessee Space Inst.
Objective: The aim of the course is to provide practicing engineers engaged in design, research and service, an in-depth background and exposure to various problems and solution techniques developed in recent years. Topics to be covered will be the fundamental principles of unsteady fluid flow, structural vibration and their interplay; review of the morphology of flow-induced vibration; state-of-the-art discussion upon theory, experimental techniques and their interaction; methodology of alleviation.

Contact: Jules Bernard, The University of Tennessee Space Institute, Tullahoma, TN 37388 - (615) 455-0631 - Ext. 276 or 277.

MACHINERY VIBRATIONS COURSE

Dates: February 26 - March 1, 1979
Place: Shamrock Hilton Hotel, Houston, Texas
Objective: This course on machinery vibrations will cover physical/mathematical descriptions, calculations, modeling, measuring, and analysis. Machinery vibrations control techniques, balancing, isolation, and damping, will be discussed. Techniques for

machine fault diagnosis and correction will be reviewed along with examples and case histories. Torsional vibration measurement and calculation will be covered.

Contact: Dr. Ronald L. Eshleman, Vibration Institute, Suite 206, 101 W. 55th St., Clarendon Hills, IL 60514 - (312) 654-2254/654-2053.

MARCH

MACHINERY VIBRATION SEMINAR
Dates: March 6-8, 1979
Place: New Orleans, Louisiana
Objective: To cover the basic aspects of rotor-bearing system dynamics. The course will provide a fundamental understanding of rotating machinery vibrations; an awareness of available tools and techniques for the analysis and diagnosis of rotor vibration problems; and an appreciation of how these techniques are applied to correct vibration problems. Technical personnel who will benefit most from this course are those concerned with the rotor dynamics evaluation of motors, pumps, turbines, compressors, gearing, shafting, couplings, and similar mechanical equipment. The attendee should possess an engineering degree with some understanding of mechanics of materials and vibration theory. Appropriate job functions include machinery designers; and plant, manufacturing, or service engineers.

Contact: Mr. Frank Ralbovsky, MTI, 968 Albany-Shaker Rd., Latham, NY 12110 - (518) 785-2349.

MEASUREMENT SYSTEMS ENGINEERING
Dates: March 12-16, 1979
Place: Phoenix, Arizona
MEASUREMENT SYSTEMS DYNAMICS
Dates: March 19-23, 1979
Place: Phoenix, Arizona
Objective: Program emphasis is on how to increase productivity, cost-effectiveness and data-validity of data acquisition groups in the field and in the laboratory. The program is intended for engineers, scientists, and managers in industrial, governmental, and educational organizations. Electrical measurements of mechanical and thermal quantities are the major topics.

Contact: Peter K. Stein, 5602 E. Monte Rosa, Phoenix, AZ 85018 - (602) 945-4603/946-7333.

APPLICATIONS OF THE FINITE ELEMENT METHOD TO PROBLEMS IN ENGINEERING
Dates: March 12-16, 1979
Place: The University of Tennessee Space Inst.
Objective: This course will concentrate on material developed recently and provide a solid foundation for those relatively new to the field. Topics to be covered are the treatment of mixed type equations which occur in transonic flow and wave motion in nonlinear solids, mixed type elements which are of importance in systems such as the Navier-Stokes equations, the interrelationship between the equation formation and the iterative scheme needed to solve any of the nonlinear equations, the advantages of hybrid elements, and the use of interactive graphics as an aid to problem solution.

Contact: Jules Bernard, The University of Tennessee Space Institute, Tullahoma, TN 37388 - (615) 455-0631, Ext. 276 or 277.

APRIL

CORRELATION AND COHERENCE ANALYSIS FOR ACOUSTICS AND VIBRATION PROBLEMS
Dates: April 16-20, 1979
Place: UCLA
Objective: This course covers the latest practical techniques of correlation and coherence analysis (ordinary, multiple, partial) for solving acoustics and vibration problems in physical systems. Procedures currently being applied to data collected from single, multiple and distributed input/output systems are explained to: classify data and systems; measure propagation times; identify source contributions; evaluate and monitor system properties, predict output responses and noise conditions; determine nonlinear and nonstationary effects; and conduct dynamics test programs.

Contact: P.O. Box 24902, Continuing Education in Engineering and Mathematics, UCLA Extension, Los Angeles, CA 90024 - (213) 825-3344/825-1295.

NEWS BRIEFS

news on current and Future Shock and Vibration activities and events

THE XIITH CONFERENCE ON MACHINE DYNAMICS

The conference will be held between April 23-27, 1979, in the High Tatra Mountains, with international participation, by the Institute of Machine Mechanics of the Slovak Academy of Sciences, in cooperation with the Institute of Thermomechanics of the Czechoslovak Academy of Sciences, the Polish Academy of Sciences and under the sponsorship of IFToMM. For further information contact the Organizing Committee, XIIth Conference on Machine Dynamics, Institute of Machine Mechanics, Slovak Academy of Sciences, 809 31 Bratislava, Czechoslovakia, Dúbravská cesta.

NOISE-CON 79
Call for Papers

NOISE-CON 79, the 1979 National Conference on Noise Control Engineering, will be held at Purdue University in West Lafayette, Indiana, on April 30 - May 2, 1979.

The theme of NOISE-CON 79 is Machinery Noise Control. Several different sessions will be held in which both invited and contributed papers will be presented. Ten sessions are presently planned on the following topics: agricultural and construction equipment noise, forging and impact noise, metal cutting noise, noise of engines and components, diagnostic measurements, measurement of noise emission, noise of machine elements, hydraulic and pneumatic system noise, mining equipment noise and noise of home appliances.

Each session in the conference will consist of invited papers and a limited number of contributed papers. Contributed papers will be selected by a review of long abstracts (maximum 1000 words and up to one figure and five equations, if needed). The deadline for these abstracts is December 15, 1978.

For more information on the conference, contact:

NOISE-CON 79
116 Stewart Center
Purdue University
West Lafayette, IN 47907

Submit abstracts to the Program Chairman:

Professor J.W. Sullivan
Ray W. Herrick Laboratories
School of Mechanical Engineering
Purdue Unviersity
West Lafayette, IN 47907
(317) 749-6345

DESIGN AND APPLICATIONS: ADVANCED COMPOSITE MATERIALS
Call for Papers

The Mechanical Failure Prevention Group (MFPG) sponsored by the National Bureau of Standards; Office of Naval Research, Department of the Navy; Department of Energy; and NASA Goddard Space Flight Center will hold its 29th Symposium at the National Bureau of Standards, Gaithersburg, Maryland on May 22-24, 1979. Papers are desired in the following areas: Applications in land, marine, and aerospace systems; Analytical techniques; Fabrication techniques; Non-destructive testing; Failure modes; Environmental effects; and Materials. Proceedings in the form of extended abstracts, 2-4 typewritten pages, will be published by the National Bureau of Standards. Closing date for initial abstracts is January 1, 1979 and for extended abstracts, April 30, 1979. Abstracts should be sent to Jesse E. Stern, Code 721, Goddard Space Flight Center, Greenbelt, Maryland 20771 - (301) 982-2657.

ABSTRACTS FROM THE CURRENT LITERATURE

Copies of articles abstracted in the DIGEST are not available from the SVIC or the Vibration Institute (except those generated by either organization). Inquiries should be directed to library resources. Government reports can be obtained from the National Technical Information Service, Springfield, VA 22151, by citing the AD-, PB-, or N- number. Doctoral dissertations are available from University Microfilms (UM), 313 N. Fir St., Ann Arbor, MI; U.S. Patents from the Commissioner of Patents, Washington, D.C. 20231. Addresses following the authors' names in the citation refer only to the first author. The list of periodicals scanned by this journal is printed in issues 1, 6, and 12.

ABSTRACT CONTENTS

ANALYSIS AND DESIGN

ANALYTICAL METHODS

78-1517

The Generalized Harmonic Balance Method for Determining the Combination Resonance in the Parametric Dynamic Systems

W. Szemplinska-Stupnicka

Inst. of Fundamental Tech. Res. of the Polish Academy of Sciences, Swietokrzyska 21, 00-049, Warsaw, Poland, J. Sound Vib., 58 (3), pp 347-361 (June 8, 1978) 9 figs, 26 refs

Key Words: Multidegree of freedom systems, Parametric excitation, Combination resonance, Harmonic balance method

For a multi-degree-of-freedom system under parametric excitation an attempt is made to generalize the harmonic balance method to the case of the combination resonance. The two harmonic components solution with uncommensurable frequencies has been assumed on the stability limits. The method has been applied to a two-degree-of-freedom system. The boundaries of the principal periodic and combination resonances have been calculated theoretically and then the results have been checked by an analog computer analysis. New essential features and peculiarities of the combination resonance have been found.

NONLINEAR ANALYSIS

78-1518

Stability of Forced Periodic Response in Third Order Non-Linear Systems

A.K. Mittal

Dept. of Appl. Mathematics, M.N. Regional Engrg. College, Allahabad-211004, India, J. Sound Vib., 58 (4), pp 579-585 (June 22, 1978) 12 refs

Key Words: Forced vibration, Periodic response, Nonlinear systems

Conditions for the stability of forced periodic response in third order non-linear systems are obtained after linearization. These conditions are consistent with results obtained by other methods.

78-1519

Study of the Random Vibration of Nonlinear Systems by the Gaussian Closure Technique

R.N. Iyengar and P.K. Dash

Dept. of Civil Engrg., Indian Inst. of Science, Bangalore, India, J. Appl. Mech., Trans. ASME, 45 (2), pp 393-399 (June 1978) 5 figs, 18 refs

Key Words: Nonlinear systems, Random vibration, Normal density functions

A technique is developed to study random vibration of nonlinear systems. The method is based on the assumption that the joint probability density function of the response variables and input variables is Gaussian. It is shown that this method is more general than the statistical linearization technique in that it can handle non-Gaussian excitations and amplitude-limited responses. As an example a bilinear hysteretic system under white noise excitation is analyzed. The prediction of various response statistics by this technique is in good agreement with other available results.

78-1520

The "Hecuba" Motions of the Restricted Three Body Problem as an Example of Nonlinear Vibrations (Die Hecubabewegung im eingeschränkten Dreikörperproblem als Beispiel einer nichtlinearen Schwingung)

E. Mettler

Geigergebirg str. 12, 7500 Karlsruhe 41, Germany, Z. Angew. Math. Mech., 58 (3), pp 121-132 (Mar 1978) 7 figs, 13 refs

Key Words: Nonlinear theories

Using the method of secular perturbations within the restricted problem of three bodies, the paper presents the motions of an asteroid revolving with nearly half the period of Jupiter as small oscillations about a steady circular motion. It is shown that the motions have the characteristic features of both forced and parametrically excited nonlinear vibrations with softening restoring force. In particular there are stable and unstable stationary vibrations corresponding with the periodic solutions and transient vibrations corresponding to the librational solutions of the restricted problem of three bodies.

NUMERICAL ANALYSIS

78-1521

An Accelerated Automatic Root Search Algorithm

for Iterative Methods in Vibration Analysis

B. Dawson and M. Davies
Div. of Engrg., Polytechnic of Central London, London, UK, Intl. J. Numer. Methods Engr., 12 (5), pp 809-820 (1978) 3 tables, 11 refs

Key Words: Iteration, Natural frequencies, Rotors, Torsional vibration

The paper presents an accelerated version of an automatic root searching technique developed by the authors for application to residual function iterative methods in vibration analysis. The power and generality of the accelerated method is demonstrated by application to an eight rotor torsional vibration system, and a fifteen rotor torsional vibration system specially synthesized so as to have an uneven root distribution including clusters of close frequencies.

OPTIMIZATION TECHNIQUES

78-1522

On the Optimization of Discrete Structures with Aeroelastic Constraints

S.C. McIntosh, Jr. and H. Ashley
Nielsen Engrg. and Res., Inc., Mountain View, CA, Computers Struc., 8 (3/4), pp 411-419 (May 1978) 2 figs, 1 table, 22 refs

Key Words: Optimization, Flutter

It is observed that modern optimal design of structures represents a confluence of two streams of theoretical development: Matrix finite element approximation on the digital computer - a technology of which Professor Argyris is one of the founders; and practical application of the variational calculus. The present paper addresses optimization problems wherein complicated constraints involving dynamic aeroelastic behavior are prominent. Search procedures based on optimality criteria are believed to offer special advantages relative to such problems.

STABILITY ANALYSIS

78-1523

Asymptotic Stability of a Class of Non-linear Singularly Perturbed Systems

J.H. Chow
Dept. of Electrical Engrg., Coordinated Science Lab., Univ. of Illinois, Urbana, IL 61801, J. Franklin Inst., 305 (5), pp 275-281 (May 1978) 1 fig, 8 refs
Sponsored by ERDA and AFOSR

Key Words: Stability analysis, Nonlinear theories, Perturbation theory

Sufficient conditions are obtained to guarantee the asymptotic stability of a class of non-linear singularly perturbed systems. A procedure for constructing a Lyapunov function for such a class of systems is given, and a clearly defined domain of attraction of the equilibrium is obtained. A stabilizing feedback control for such systems is also proposed.

78-1524

An Investigation of the Buckling Behaviour and Parametric Resonance Phenomenon of a Tensioned Sheet with a Central Opening

P.K. Datta
Dept. of Aeronautical Engrg., Indian Inst. of Tech., Kharagpur 721302, West Bengal, India, J. Sound Vib., 58 (4), pp 527-534 (June 22, 1978) 7 figs, 9 refs

Key Words: Hole-containing media, Parametric resonance, Dynamic stability

The results of an experimental study of the buckling behavior and parametric resonance phenomenon of a tensioned sheet with a rectangular opening having elliptic ends are presented. The data from the static experiments indicate that the local buckling phenomena of the free edge of the opening are dependent on cutout parameters. The variations of critical buckling stress on opening parameters are discussed. The parametric excitation experiments show two distinct types of resonant behavior. The response-excitation frequency ratio is observed to be half for the principal region and the ratio is one for the secondary region. The size and amplitude of oscillations of the principal regions are found to be substantially larger than that of the secondary region. Further, parametric resonance experiments for different opening parameters indicate that the dynamic instability effects are more significant for narrow openings than for wider openings.

FINITE ELEMENT MODELING

(Also see Nos. 1554, 1622, 1669, 1671)

78-1525

Finite-Element Methods for Nonlinear Elastodynamics Which Conserve Energy

T.J.R. Hughes, T.K. Caughey, and W.K. Liu

Div. of Engrg. and Appl. Science, California Inst. of Tech., Pasadena, CA., J. Appl. Mech., Trans. ASME, 45 (2), pp 366-370 (June 1978) 4 figs, 1 table, 10 refs

Key Words: Finite element technique, Transient analysis, Nonlinear theories

A modification of the trapezoidal rule is presented which results in physically appropriate energy growth characteristics for nonlinear transient analysis. In particular, when external forces are absent, energy conservation is attained for nonlinear elastodynamics and unconditional stability is thereby automatically achieved. Implementation aspects and numerical examples in support of the theory are described.

78-1526

Implicit-Explicit Finite Elements in Transient Analysis: Stability Theory

T.J.R. Hughes and W.K. Liu

Div. of Engrg. and Appl. Science, California Inst. of Tech., Pasadena, CA., J. Appl. Mech., Trans. ASME, 45 (2), pp 371-374 (June 1978) 1 fig, 13 refs

Key Words: Finite element technique, Transient analysis

A stability analysis is carried out for a new family of implicit-explicit finite-element algorithms. The analysis shows that unconditional stability may be achieved for the implicit finite elements and that the critical time step of the explicit elements governs for the system.

78-1527

Implicit-Explicit Finite Elements in Transient Analysis: Implementation and Numerical Examples

T.J.R. Hughes and W.K. Liu

Div. of Engrg. and Appl. Science, California Inst. of Tech., Pasadena, CA., J. Appl. Mech., Trans. ASME, 45 (2), pp 375-378 (June 1978) 5 figs, 1 table, 16 refs

Key Words: Finite element technique, Transient analysis

Computer implementation aspects and numerical evaluation of a new family of implicit-explicit finite element, transient algorithms are presented. It is shown that the new methods are easily coded, and may be introduced into many existing implicit, finite-element codes with only slight modification. Numerical tests confirm the theoretical stability and accuracy characteristics of the methods presented in a companion paper.

78-1528

A One-Sweep Method in the Solution of Finite-Element Equations: An Application to the Vibration of Structures in Heavy Fluids

N. Distefano and H. Chiu

Tetra Tech., Pasadena, CA., J. Optimization Theory Appl., 23 (1), p 27 (Sept 1977) 7 figs, 6 refs

Key Words: Cylinders, Submerged structures, Finite element technique

A one-sweep method for the numerical solution of finite-element equations is presented. This procedure is especially efficient in computing time and storage when the solution is required at only a few nodes of the finite-element mesh. Furthermore, the method is particularly useful in dealing with problems on infinite or semi-infinite domains. Artificial boundaries must be introduced in such cases, and the one-sweep method affords an extremely efficient algorithm by which the dependence of the solution on the location of these boundaries can be assessed. An application of the method to the vibration of a half-submerged circular cylinder in a heavy fluid is presented.

78-1529

Finite Element Analysis for Complex Structures (Helicopter Transmission Housing Structural Modeling)

R.W. Howells and J.J. Sciarra

Boeing Vertol Co., Philadelphia, PA, Rept. No. D210-11232-1, USAAMRDL-TR-77-32, 216 pp (Jan 1978)

AD-A052 759/8GA

Key Words: Helicopters, Transmissions, Housings, Finite element technique

The objective of the Finite Element Analysis for Complex Structures program was to develop and demonstrate a comprehensive, finite element analytical technique with the capability and flexibility for analyzing helicopter transmission housings made of metal and/or composite materials. The work encompassed the study of thermal distortion and stress stress, and deflection due to static and dynamic loads, load path definition, dynamic response and the control of structural energy distribution. The results were used to optimize strength and weight, and to assess operational housing life, failsafety/safe life, and reliability. Some emphasis was placed on heat transfer analyses.

MODELING

78-1530

Improvement of Dynamic Models by Inverse Eigenproperty Assignment

G. Fradellos and F.J. Evans

Dept. of Electrical and Electronic Engrg., Queen Mary College, Univ. of London, Mile End Road, London E1 4NS, UK, Appl. Math. Modeling, 2 (2), pp 123-129 (June 1978) 2 figs, 11 refs

Key Words: Mathematical models, Eigenvalue problems

A particular mathematical model often produces results which disagree with data taken from the actual system. It is important to be able to adjust the data used in the calculation of the modes of behavior to give better agreement between measured and calculated performance, thus showing the desired characteristics. This procedure is seen in terms of the generation of the input vector of the system by appropriate linear feedback of the state vector, such that prescribed eigenproperties are associated with the resultant dynamic closed-loop system. The technique is illustrated by an application in macroeconomics.

DIGITAL SIMULATION

78-1531

Simulation of Continuous Systems by Periodic Structures

R.C. Engels and L. Meirovitch

Dept. of Engrg. Science and Mechanics, Virginia Polytechnic Inst. and State Univ., Blacksburg, VA., J. Appl. Mech., Trans. ASME, 45 (2), pp 385-392 (June 1978) 5 figs, 4 refs

Key Words: Continuum mechanics, Simulation, Periodic structures

Many continuous systems can be approximated by periodic structures where periodic structures are structures consisting of identical substructures, connected to each other in identical manner. An efficient algorithm developed by these authors for the response of periodic structures is adapted to the treatment of continuous systems. The method is capable of deriving the response of damped or undamped systems subject to harmonic distributed loads. The length of the substructure can be made arbitrarily small without increasing the computational effort. Furthermore, the number of degrees of freedom of the substructure can be reasonably large.

PARAMETER IDENTIFICATION

(Also see No. 1581)

78-1532

A Mathematical Model to Predict the Inelastic Response of a Steel Frame: Formulation of the Model

H.D. McNiven and V.C. Matzen

Univ. of California, Berkeley, CA., Intl. J. Earthquake Engr. Struc. Dynam., 6 (2), pp 189-202 (Mar/Apr 1978) 5 figs, 21 refs

Key Words: Framed structures, Steel, Earthquake response, System identification technique, Mathematical models

The purpose of this research is to use data from experiments to formulate a mathematical model that will predict the non-linear response of a single-story steel frame to an earthquake input. The process used in this formulation is system identification. The form of the model is a second-order non-linear differential equation with linear viscous damping and Ramberg-Osgood type hysteresis. The damping coefficient and the three parameters in the hysteretic model are to be established. An integral weighted mean squared error function is used to evaluate the 'goodness of fit' between the model's response and the structure's response when both are subjected to the same excitation.

78-1533

A Mathematical Model to Predict the Inelastic Response of a Steel Frame: Establishment of Parameters from Shaking Table Experiments

V.C. Matzen and H.D. McNiven

North Carolina State Univ. at Raleigh, NC., Intl. J. Earthquake Engr. Struc. Dynam., 6 (2), pp 203-219 (Mar/Apr 1978) 15 figs, 4 refs

Key Words: Framed structures, Steel, Earthquake response, System identification technique, Experimental data, Shakers

The purpose of this research is to use data from experiments to formulate a mathematical model that will predict the non-linear response of a single-story steel frame to an earthquake input. The process used in this formulation is system identification. In experiments performed on a shaking table, the frame was subjected to two earthquake motions at several intensities. In each case the frame underwent severe inelastic deformation. A computer program which incorporates the concepts of system identification makes use of the recorded data to establish four parameters in a non-linear mathematical model. When different amounts of data are used in the program, parameter sets are established which give the best model response for that amount of test data. The resulting sets of parameters reflect the way in which the properties of the structure change during the excitation.

DESIGN TECHNIQUES

78-1534

Continuous Time Simulation of Forces and Motion within an Automotive Engine

R.L. Norling

Engineering Staff, General Motors, SAE Paper No. 780665, 16 pp, 10 figs, 4 refs

Key Words: Motor vehicle engines, Computer-aided techniques, Design techniques

A general purpose model of the internal combustion engine with time as the continuous independent variable has been derived for digital computer simulation. A significant advantage rests in the graphic display of maximum and minimum values of component forces and torques, or any model variable, as a function of crank angle. The differential equations of motion that describe component positions, velocities and acceleration were combined to describe the dynamics of the entire engine. Gas forces, as well as static, viscous and velocity-dependent friction terms, have been included. The IBM Continuous System Modeling Program (CSMP), was used to describe the engine and solve the equations. The model is easily adaptible to many engine configurations.

CRITERIA, STANDARDS, AND SPECIFICATIONS

(Also see No. 1561)

78-1535

A Legal Overview of the OSHA Noise Standard at 29 CFR 1910.95 (b) (1)

P.T. Parashes

White and Williams, Philadelphia, PA, S/V, Sound Vib., 12 (6), pp 10-19 (June 1978) 2 tables, 161 refs

Key Words: Noise reduction, Industrial facilities, Standards and codes

This article reviews decisions which have established what must be shown by the U.S. Department of Labor in order to prove that noise exposure limits were exceeded within a specific workplace. It also focuses on decisions dealing with the more complex and controversial issue of what the word "feasible" means in the context of the noise standard. The goal of the article is to impart a basic understanding of the present state of Occupational Safety and Health Review Commission law regarding the noise standard and some insight into the areas in which changes are most likely to occur in future decisions.

78-1536

The OSHA Noise Standard - How to Live with It

A.S. Heggie

Donley, Miller & Nowikas, Inc., East Hanover, NJ, S/V, Sound Vib., 12 (6), pp 20-25 (June 1978) 2 figs, 4 tables

Key Words: Noise reduction, Industrial facilities, Standards and codes

Since October, 1974, when revisions to the noise standard were proposed by OSHA, there has been growing confusion over what is required and how to meet the regulations. Plant management might be forgiven under these circumstances if they took no action at all, but such a decision will not prevent OSHA citations for noise violation, nor will it halt the rise in hearing compensation for partial hearing loss. For those who have to live with it, it is important to keep costs to a minimum while at the same time achieve practical and sensible objectives.

78-1537

Noise Control - A Statutory Duty

C. Deurden

Noise Control Vib. Isolation, pp 192-195 (May 1978)

Key Words: Noise reduction, Regulations

Industrial noise control legislation particularly at construction and demolition sites in Great Britain is described.

78-1538

Seismic Design: Cost Impact on High-Rise Residential Structures

Severud-Gruzen-Turner, NY, Rept. No. HUD/RES-1250, 201 pp (Sept 1977)

PB-278 352/0GA

Key Words: Multistory buildings, Seismic design, Standards and codes

This research study examines the cost impact of providing increased seismic resistance for prototype high-rise apartment buildings. Eleven U.S. cities were chosen as case studies. Structures were designed to meet the Local Building Codes and seismic requirements therein, if any, and were redesigned to meet the seismic criteria of the HUD Minimum Property Standards for Multifamily Housing, 4910.1 and the Uniform Building Code 1973. Also the Uniform Building Code 1976 was used to examine the cost impact of this code in two of the case study cities. The cost impact generally proved to be greatest for cities which use their own local code requirements rather than that of one of the National Model Codes.

78-1539

Airport and Aircraft Noise Reduction

Committee on Public Works and Transportation, U.S. House, Rept. No. GPO-91-591, 590 pp (1977) N78-21891

Key Words: Aircraft noise, Noise reduction, Regulations

The establishment of a comprehensive program for the systematic reduction of noncompatible land uses in areas surrounding certain airports in the United States and the level of noise created by aircraft operating at such airports was discussed in testimony delivered and statements submitted for the record during House hearings on the resolution. The text of the bill is included.

SURVEYS AND BIBLIOGRAPHIES

78-1540

Circular Saw Vibration Research

C.D. Mote, Jr. and R. Szymani

Dept. of Mech. Engrg., Univ. of California, Berkeley, CA 94720, Shock Vib. Dig., 10 (6), pp 15-30 (June 1978) 7 figs, 123 refs

Key Words: Reviews, Saws

Current research in circular saw vibration is evaluated. Fundamental investigations having potential long-term importance in the area of circular saw vibration are reviewed.

78-1541

Sound Attenuation Over Ground Cover

K. Attenborough

Faculty of Tech., The Open Univ., Milton Keynes, MK7 6AA, UK, Shock Vib., 10 (7), pp 3-13 (July 1978) 3 figs, 30 refs

Key Words: Sound attenuation, Point source excitation, Reviews

This review covers recent developments in the solution of the problem of a point source above an absorbing plane with particular reference to the approximations which have been made in order to simplify numerical calculation. The physical significance of these approximations is outlined. Various assumed models for the ground surface are classified and explored.

78-1542

Recent Research on the Dynamic Response of Fluid-Filled Shells

F.L. DiMaggio

Dept. of Civil Engrg. and Engrg. Mechanics, Columbia Univ., New York, NY, Shock Vib. Dig., 10 (7), pp 15-19 (July 1978) 3 figs, 27 refs

Key Words: Reviews, Shells, Fluid-filled containers

This article reviews papers, published between 1975 and 1978, involving the dynamic response of fluid-filled shells. Papers considering gravity effects or fluid flow are not reviewed.

78-1543

On Seismic Waves. Part II: Surface Waves and Guided Waves

S. De

Old Engineering Office (Qrs.), Santiniketan, Birbhum, West Bengal, India, Shock Vib. Dig., 10 (6), pp 9-14 (June 1978) 50 refs

Key Words: Reviews, Seismic waves

In theory, many types of surface and guided waves can exist in the earth. They include Rayleigh waves in the continental and oceanic crust, Rayleigh waves in the mantle, Love waves in the continental and oceanic crust, G waves in the mantle, Lg and Rg waves, Sofar waves and T phases in the ocean, Surface waves generated by explosion, Fundamental modes of vibration and low order overtones on earth. Several of these wave types are described in this second part of the article.

78-1544

On Seismic Waves. Part III: Mathematical Methods

S. De

Old Engineering Office (Qrs.), Santiniketan, Birbhum, West Bengal, India, Shock Vib. Dig., 10 (7), pp 21-43 (July 1978) 276 refs

Key Words: Seismic waves, Reviews

The frequency equations for the Rayleigh and Love waves in various models of the earth – from a single half-space to multilayered semi-infinite media – are well known. Some of the layers are considered to be heterogeneous or anisotropic. Because suitable solutions for the equations of motion for most cases of lateral nonhomogeneity are not possible, the principle of constructive interference associated with the ray theory is used to derive the frequency equation. The Thomson-Haskell matrix method has been applied to multilayered media. This article and the last article in the series describe various mathematical methods used to study seismic waves.

78-1545

System Reliability Assessments Using Critical Excitations

R.F. Drenick and P.C. Wang

Polytechnic Inst. of New York, 333 Jay St., Brooklyn, NY 11201, Shock Vib. Dig., 10 (6), pp 3-7 (June 1978) 1 fig, 11 refs

Sponsored by the National Science Foundation

Key Words: Reviews, Reliability

Critical and certain related excitations are applied to mechanical and structural reliability problems involving the assessment of the resistance of systems to dynamic loads whose characteristics are partly or largely unknown. The experience gained thus far in practical situations and possible extensions of the use of the technique are described. Dependable, but somewhat conservative, reliability assessments have been achieved that might be applicable to various systems.

78-1546

Highway Safety Structures (A Bibliography with Abstracts)

E. Kenton

National Technical Information Service, Springfield, VA., Rept. No. NTIS/PS-78/0401/6GA, 128 pp (Apr 1978)

Key Words: Bibliographies, Highway barriers, Energy absorption, Guardrails

Documentation is made of various structures and mechanical devices for promoting highway safety. Reports pertain to highway signs and displays, barriers, medians, breakaway poles and supports, crash cushions, parapets, guard rails, curbs, and fences. Discussions are presented of impact attenuators, arrester beds, and other safety appurtenances. Also noted are median grates, redirecting curbs, and other installations. Some attention is given to tests and methodology.

TUTORIAL

78-1547

Summer Seismic Institute for Architectural Faculty Held at Stanford University, California on August 7-12, 1977

J.P. Eberhard, E.W. Kennett, and B.D. Frazier

AIA Research Corp., Washington, D.C., Rept. No. NSF/RA-770404, 307 pp (Oct 1977)

PB-277 958/5GA

Key Words: Buildings, Seismic design, Standards and codes

This Institute was convened for the purpose of bringing concerns of earthquake safety more broadly into the architectural community. Participants were faculty members from schools of architecture throughout the United States. Objectives of the Institute were to present basic seismic knowledge to the participants, to allow them an opportunity to apply this gained knowledge, and to develop strategies for integrating this knowledge into the curricula of schools of architecture across the country.

MODAL ANALYSIS AND SYNTHESIS

78-1548

On Suitable Formulations of the Method of Modal Analysis for Numerical Calculations

E. Gossmann, W. Krings, and H. Waller

Institut f. Mechanik, Ruhr-Universität Bochum, Bochum, West Germany, Intl. J. Numer. Methods Engr., 12 (5), pp 795-808 (1978) 5 figs, 4 tables, 5 refs

Key Words: Modal analysis, Multi degree of freedom systems, Laplace transformation

The method of modal analysis is a method widely used in structural analysis of linear systems. After a short introduction two step by step formulations for modal calculations are discussed. One of them is of more theoretical interest, the other is recommended for practical calculations for multi-degree-of-freedom systems because it is efficient in computing time. The first is formulated for the whole system, the latter for each mode. Likewise a combination of the method of modal analysis and the Laplace transformation is established. The numerical calculation of the Laplace transformation is done by using the algorithm of the Fast Fourier transformation. The advantages of the different formulations for numerical calculations are discussed.

COMPUTER PROGRAMS

GENERAL

(Also see Nos. 1623, 1628, 1629, 1659, 1671, 1678)

78-1549

A Comparison of Computed Versus Experimental Loading and Response of a Flat Plate Subjected to Mine Blast

R.E. Lottero and K.D. Kimsey

Ballistics Res. Lab., Army Armament Res. and Dev. Command, Aberdeen Proving Ground, MD, Rept. No. ARBRL-MR-02807, AD-E400 112, 53 pp (Jan 1978)

AD-A051 933/0GA

Key Words: Computer programs, Plates, Blast response, Mines (ordnance)

The DORF hydrocode is used to generate the loading history on a target plate subjected to the blast loading from a buried land mine. The REPSIL structural response code is used to compute the response of the target plate to this loading. The deflection of a clamped-edge, square, target plate of rolled loading.

78-1550

Documentation for the SHORE-III Finite Element Computer Program. Part 1: Theoretical Manual. Part 2: Users' Manual

P.K. Basu and P.L. Gould

Dept. of Civil Engrg., Washington Univ., St. Louis, MO, Rept. No. RR-48, RR-49, NSF/RA-770406, 175 pp (Sept 1977)

PB-277 911/4GA

Key Words: Computer programs, Shells, Plates, Finite element technique

Part 1, the theoretical manual, describes the software designed for the static and dynamic analysis of axisymmetric shells and plates. The SHORE-III program is written in Fortran IV language. Part 2, the users' manual, explains how the SHORE-III program can be used for the static and dynamic analysis of arbitrarily loaded thin elastic shells of revolution with or without column supports, in the elastic regime. The users' manual describes the procedure to be followed in preparing the input data for this program and also assists in the interpretation of the output. A number of sample inputs and outputs using the various options of the program are included.

78-1551

Documentation of Helicopter Aeroelastic Stability Analysis Computer Program (HASTA)

L.R. Sutton

Rasa Div., Systems Res. Labs., Inc., Newport News, VA, Rept. No. RASA/SRL-14-77-04, USARTL-TR-77-52, 411 pp (Dec 1977)

AD-A053 022/0GA

Key Words: Computer programs, Manuals and handbooks, Helicopter rotors, Vibration resonance

This report is the documentation manual for the computer program Helicopter Aeroelastic Stability Analysis (HASTA). The HASTA program predicts the air resonance behavior of coupled rotor/helicopter support structure systems including rotor drive shaft torsional flexibility, anisotropic gearbox support flexibility, and control system anisotropic flexibility. The consideration of rigid, articulated, gimballed, teetering, flexstrap, and bearingless rotor systems is allowed. This manual contains: a description of the method of solution, a list of program variables, a discussion of the equations, a listing of the program, instructions on the use of the program, sample input and output listing, and additional information pertaining to the computer program.

78-1552

FAA Integrated Noise Model Version 1, Basic User's Guide

Office of Environmental Quality, Federal Aviation Administration, Washington, D.C., Rept. No. FAA-EQ-78-01, 113 pp (Dec 1977)

AD-A052 790/3GA

Key Words: Computer programs, Aircraft noise

The document contains a basic description of the application of the Integrated Noise Model, (INM), Version 1. The INM is a collection of computer programs which can be used to simulate aircraft operations at airports and display the noise contribution of those operations to the environment in the vicinity of the airport. The INM consists of three nonconversational applications programs which are executed without any direct interaction with either the user or the operations system under which they are run. The three applications models are: The Grid Analysis Model; The Contour Analysis Model; and The Contour Plotting Package. For acceptable definitions of aircraft operations, the model is capable of computing any or all of the following noise exposure measures: Noise Exposure Forecast (NEF); Equivalent Sound Level (Leq); Day Average Sound Level (Ldn); Community Noise Equivalent Level (CNEL); and Time above a Threshold of A-Weighted Sound Level (TA). The document is designed to serve as a guide for the user, management personnel, and the consultant. This guide will provide the means of applying the INM without the use of sophisticated forms or processes, and the consultant. This guide will provide the means of applying the INM without the use of sophisticated forms or processes.

ENVIRONMENTS

ACOUSTIC

(Also see Nos. 1532, 1533, 1541, 1552, 1594, 1598, 1635, 1636, 1637, 1638, 1650, 1651, 1653, 1663, 1675, 1676)

78-1553

Low Frequency Bloch Waves for Wave Equations Whose Speed is a Deterministic, or Randomlike, Periodic Function

G.N. Balanis
Arete Associates, Santa Monica, CA, J. Appl. Mech., Trans. ASME, 45 (2), pp 331-336 (June 1978) 12 refs

Key Words: Elastic waves, Sound waves, Wave propagation

This paper examines the low frequency behavior of the Bloch wave solution to wave equations whose sound speed is a three-dimensional periodic or almost-periodic function of position. The case where the sound speed is a randomlike function of position is also considered. The low frequency dependence of the Bloch wave phase velocity is obtained as a power series in the frequency. The freuqency independent term is related to the average value of the inhomogeneities and is independent of the direction of propagation. The first dispersive term, which is also independent of the direction of propagation, is quadratic in frequency. Its coefficient is related to the spatial correlation of the inhomogeneities.

78-1554

The Finite Element Method at Acoustical Problems

R. Piltner
VDI Z., 120 (9), pp 483-490 (1978) 4 figs, 3 tables, 4 refs

Key Words: Acoustic properties, Finite element technique

The method of finite elements has already proved itself as an excellent auxiliary means in the structural mechanics. Its application to the treatment of acoustical problems, however, is not as popular up to now. Therefore, the author attempts to give a survey on the method – which certainly will gain in future more and more importance in acoustics – and also on some problems and some difficulties, which will occur at the application of this method in the range of acoustics. The explanation of the flow of deduction of a finite element is carried out by way of example of a two-dimensional problem by means of variation principles. The method of W. Ritz is being used for the deduction of the element matrices. The contribution includes finally the formualtion of a problem as a system of differential equations with temporary derivatives, the solution of which is achieved by means of the model analysis.

78-1555

Studies with an Eccentric Bell

T. Charnley and R. Perrin
Dept. of Physics, Loughborough Univ. of Tech., Loughborough LE11 3TU, UK, J. Sound Vib., 58 (4), pp 517-525 (June 22, 1978) 6 figs, 4 tables, 6 refs

Key Words: Bells, Vibration measurement

Vibration measurements have been made on a highly eccentric bell. Only negligible splitting of most partials was observed, thus casting doubt on the ability of group theory to handle this type of problem adequately. The implications for warble suppression are discussed.

78-1556

Acoustic Scattering by Membranes and Plates with Line Constraints

F.G. Leppington
Dept. of Mathematics, Imperial College of Science and Tech., London SW7 2BZ, UK, J. Sound Vib., 58 (3), pp 319-332 (June 8, 1978) 2 figs, 10 refs

Key Words: Acoustic scattering, Membranes, Plates

A plane sound wave is incident upon an infinite membrane (or thin elastic plate) that is held fixed along two or more parallel lines. A formally exact solution is found and is investigated in the limiting cases of large and small fluid loading, with emphasis on resonance effects in the latter case.

78-1557

Acoustical Measuring Procedures in Automobile Development

H. Hartwig and P. Seifert
Volkswagenwerk AG, Bereich Forschung/Entwicklung, Postfach, 3180 Wolfsburg, Germany, Techn. Messen (ATM), 45 (3), pp 101-103 (Mar 1978); 45 (4), pp 141-146 (Apr 1978); 45 (5), pp 189-194 (May 1978) 43 figs, 33 refs
(In German)

Key Words: Ground vehicles, Vehicles, Noise measurement, Measurement techniques

The total noise of a vehicle results from the sum of many single noise sources. The main source is the engine, including intake and exhaust system. The exterior noise is measured by a legally prescribed pass-by method and additionally stationary in the proximity of the car. The basis for studying interior noise is the separation of structure noise and airborne noise and the study of the corresponding noise-paths. The airborne noise of the engine-gearbox-aggregat is measured on a test stand in the reverberation room with certain parts successively removed. Accelerometer-measurements are made at the aggregat which is hung up undercritical in springs. The transfer of structure noise by the connections between engine and car body is studied by comparing measurements of interior noise on a rolling bench in an anechoic chamber by removing certain bridges of structure noise successively.

78-1558

Concorde Noise-Incuced Building Vibrations, John F. Kennedy International Airport

W.H. Mayes, R. DeLoach, D.G. Stephens, J.M. Cawthorn, H.K. Holmes, R.B. Lewis, B.G. Holliday, W.T. Miller, and D.W. Ward
Langley Res. Center, NASA, Langley Station, VA, Rept. No. NASA-TM-78676; Rept-2, 67 pp (Feb 1978)
N78-20919

Key Words: Aircraft noise, Buildings, Acoustic excitation, Vibration response, Fluid-induced excitation, Human response

The outdoor/indoor noise levels and associated vibration levels resulting from aircraft and nonaircraft events were recorded at eight homesites and a school. In addition, limited subjective tests were conducted to examine the human detection/annoyance thresholds for building vibration and rattle caused by aircraft noise. Presented herein are the majority of the window and wall vibration data recorded during Concorde and subsonic aircraft overflights.

78-1559

Construction-Site Noise Control Cost-Benefit Estimating Procedures

F.M. Kessler, P.D. Schomer, R.C. Chanaud, and R. Rosendahl
Construction Engrg. Res. Lab (Army), Champaign, IL, Rept. No. CERL-IR-N-36, 35 pp (Jan 1978)
AD-A051 737/5GA

Key Words: Construction industry, Noise reduction

This report aids the U.S. Army Corps of Engineers construction cost estimator in determining the level of noise generated at construction sites, in comparing this level with Corps of Engineers criteria, and in estimating costs to a contractor of reducing the noise. A companion report, Construction-Site Noise Control-Cost-Benefit Estimation Technical Background, Technical Report N-37 (U.S. Army Construction Engineering Research Laboratory (CERL), January 1978), contains the rationale and data supporting this report.

78-1560

Plant Design Guidelines for Noise Exposure Control

H. Chang
Bechtel Corp., San Francisco, CA., S/V, Sound Vib., 12 (5), pp 12-15 (May 1978) 3 figs, 15 refs

Key Words: Industrial facilities, Noise control, Human response

This article illustrates a systematic approach to reduce occupational noise exposure in heavy industrial plants. By reviewing engineering design drawings, potential noise sources are identified and the noise levels within the plant are predicted. Occupational noise doses are evaluated based on the predicted noise levels and the expected exposure durations of employees. Critical areas can thus be identified and appropriate control measures recommended to reduce occupational noise exposures for normal plant operation.

78-1561

Controlling Power-Plant Noise

A.M. Teplitzky
Consolidated Edison Co. of New York Inc., Power, 122 (8), pp 23-27 (Aug 1978) 3 figs, 3 tables, 9 refs

Key Words: Electric power plants, Noise reduction, Regulations

This article reviews the science of acoustics, identifies pertinent regulations, summarizes some of the practical methods for reducing power-plant noise, and takes a look at noise-control costs.

78-1562

Stationary Locomotive In-Cab Noise Measurements

R.M. Clarke

Federal Railroad Administration, Washington, D.C., S/V, Sound Vib., 12 (5), pp 18-19, 22-23 (May 1978) 5 figs, 9 refs

Key Words: Locomotives, Noise generation, Noise measurement, Human response

The U.S. Federal Railroad Administration (FRA), in cooperation with the Association of American Railroads, is sponsoring efforts by the National Bureau of Standards to collect locomotive in-cab noise level data. The purpose of the program is to develop a simplified stationary test procedure which will yield data that correlate with crew noise exposures for typical operational duty cycles, and which will provide data to relate to OSHA hearing conservation regulations.

RANDOM

(See No. 1614)

SEISMIC

(Also see Nos. 1538, 1543, 1544, 1547, 1582, 1583, 1610, 1627, 1645, 1647, 1648)

78-1563

A Random Process for Earthquake Simulation

T.-I. Hsu and M.C. Bernard

Dept. of Civil Engrg. and Engrg. Mechanics, McMaster Univ., Hamilton, Ontario, Canada, Intl. J. Earthquake Engr. Struc. Dynam., 6 (4), pp 347-362 (July/Aug 1978) 17 figs, 5 tables, 19 refs

Key Words: Earthquake excitation, Simulation

Some existing models for the simulation of earthquake acceleration show the difficulties in determining the involved parameters and in describing frequency content. A non-stationary modulated random process obtained as the product of a time envelope function and a stationary random function is used to simulate earthquake acceleration. The parameters and the distribution of frequencies of the simulation process are obtainable from past earthquake records. This simple and realistic model is suggested for use as the input process in aseismic design of structures.

SHOCK

(Also see Nos. 1601, 1628, 1629, 1654, 1655, 1678, 1679)

78-1564

Standby Redundant Systems in Random Environment

L. Råde

Chalmers Tekniska Högskola och Göteborgs Universitat, Matematiska Institutionen, Fock, 40220 Göteborg, Sweden, Z. Angew. Math. Mech., 58 (3), pp 155-161 (Mar 1978) 4 figs, 8 tables, 7 refs

Key Words: Reliability, Shock response

Reliability systems with one or two redundant standby components are studied. The systems are situated in a random environment which generates shocks according to a renewal point process. The shocks will cause a component to fail with a certain probability. Failed components are immediately repaired and the repair times are exponentially distributed. Special consideration is given to systems with cold and with warm standby components. Numerical studies are made of the effect of standby and of repair when shocks are generated by a Poisson process.

78-1565

Blast Tests of Expedient Shelters in the DICE Throw Event

C.H. Kearny and C.V. Chester

Oak Ridge National Lab., Oak Ridge, TN, Rept. No. ORNL-5347, 90 pp (Mar 1978)

AD-A052 913/1GA

Key Words: Protective shelters, Blast resistant structures, Blast response

To determine the worst blast environments that eight types of expedient shelters can withstand, a total of 18 shelters were subjected to the 1-kiloton blast effects of Defense Nuclear Agency's DICE THROW main event. These expedient shelters included two Russian and two Chinese types.

78-1566

On Dynamic Plastic Mode-Form Solutions

P.S. Symonds and C.T. Chon

Div. of Engrg., Brown Univ., Providence, RI 02912, J. Mech. Phys. Solids, 26 (1), pp 21-35 (Feb 1978) 7 figs, 10 refs

Key Words: Dynamic plasticity, Plates

Discussion is given of the significance and calculation of dynamic plastic mode-form solutions for small deflections of structures of rigid perfectly-plastic materials subjected to load systems of fixed distribution and magnitude. These solutions have separated form, with velocity the product of a scalar function of time by a vector-valued function of space variables. The relation is shown on the one hand to mode-form solutions for a structure of viscoplastic material, and on the other hand to limit-load solutions for those of perfectly-plastic behavior. Numerical examples are given for circular plates of material obeying the Tresca and Mises laws.

78-1567

Upgrading Basements for Combined Nuclear Weapons Effects: Predesigned Expedient Options

H.L. Murphy
Sri International, Menlo Park, CA, 205 pp (Oct 1977)
AD-A054 409/8GA

Key Words: Protective shelters, Nuclear weapons effects

This document continues the Phase 1 work reported in AD-A030 762. That contract was concerned with evaluation of a few specific structures, and devising expedient options for upgrading their structural resistance to blast.

GENERAL WEAPON

(See Nos. 1549, 1567)

PHENOMENOLOGY

DAMPING

(Also see No. 1639)

78-1568

Development of Procedures for Calculating Stiffness and Damping Properties of Elastomers in Engineering Applications. Part 4: Testing of Elastomers Under a Rotating Load

M.S. Darlow and A.J. Smalley
Mechanical Techology, Inc., Latham, NY, Rept. No. NASA-CR-135355; MTI-78TR18-Pt-4, 87 pp (Nov 1977)
N78-22402

Key Words: Elastomers, Stiffness coefficients, Damping coefficients, Experimental results

A test rig designed to measure stiffness and damping of elastomer cartridges under a rotating load excitation is described. The test rig employs rotating unbalance in a rotor which runs to 60,000 RPM as the excitation mechanism. A variable resonant mass is supported on elastomer elements and the dynamic characteristics are determined from measurements of input and output acceleration. Five different cartridges are considered: three of these are buttons cartridges having buttons located in pairs, with 120 between each pair. Two of the cartridges consist of 360 elastomer rings with rectangular cross-sections. Dynamic stiffness and damping are measured for each cartridge and compared with predictions at different frequencies and different strains.

78-1569

Continuum Description of Hysteresis Damping of Vibrations

T.H. Dawson
Dept. of Naval Systems Engrg., U.S. Naval Academy, Annapolis, MD 21402, Intl. J. Solids Struc., 14 (6), pp 457-464 (1978) 3 figs, 13 refs

Key Words: Hysteretic damping, Torsional vibration, Wire

A continuum description of hysteresis damping of vibrations is constructed based on the assumption that the hysteresis in the elastic response is due to the occurrence of small plastic strains below the over-all elastic limit of the material. The associated constitutive law describing elasticity with hysteresis is developed assuming the plastic strain rate for loading is dependent only on the stress and stress rate. It is shown that the constitutive law so developed yields the well-known Kimball-Lovell quadratic damping law for sufficiently low stress levels and that it provides additional terms for describing damping when higher stress levels are involved. The theory is applied to the free torsional vibration of wires and is shown to yield exponential amplitude decay for low stress levels. Detailed theoretical results are compared with measurements of the torsional response of a soft copper wire.

78-1570

A Note on Vibrations of Damped Linear Systems

D.W. Nicholson
The Goodyear Tire and Rubber Co. Akron, OH, Mech. Res. Comm., 5 (2), pp 79-83 (1978) 5 refs

Key Words: Transient response, Damped structures, Linear systems

In a damped linear system, for the free vibrations to be oscillatory witn decaying amplitude, it is proven that the mass and damping matrices must be positive definite. Also, a certain matrix product involving the mass, damping and stiffness matrices must be commutative.

78-1571

On the Forced Vibration of a Damped Linear System

D.W. Nicholson
The Goodyear Tire and Rubber Co., Akron, OH, Mech. Res. Comm., 5 (2), pp 73-77 (1978) 3 refs

Key Words: Forced vibration, Damped structures, Linear systems, Boundary value problems

For a damped linear system in forced vibration, a bound on the norm of the repsonse vector is derived in terms of the smallest eigenvalue of the stiffness matrix and of the damping matrix, and the largest eigenvalue of the mass matrix.

ELASTIC

(Also see No. 1553)

78-1572

The Influence of Random Porosity on Elastic Waves Propagation

A. Beltzer
Center for Technological Education, Tel-Aviv Univ., 52 Golomb St., P.O.B. 305, Holon, Israel, J. Sound Vib., 58 (2), pp 251-256 (May 22, 1978) 2 figs, 17 refs

Key Words: Elastic waves, Wave propagation, Porous materials

A stochastic model of porosity is presented which includes size, number and configuration of the pores as random parameters. In particular, the porosity may be described by the Poisson stochastic process. The propagation of a plane longitudinal elastic wave is treated under the condition that the pore concentration is small. The disperison relation and the attenuation expression are averaged for an ensemble of specimens.

78-1573

Elastic Dispersion, Homogeneous Dispersive Media and an Application to Periodic Elastic Media

G.N. Balanis
Arete Associates, Santa Monica, CA, J. Appl. Mech., Trans. ASME, 45 (2), pp 337-342 (June 1978) 20 refs

Key Words: Wave propagation, Elastic media

Wave dispersion that occurs without energy loss is examined and media capable of supporting waves with such dispersion are developed. The media are homogeneous and dispersive. The dispersion of the waves they generate shares many of the characteristics of the dispersion of waves propagating through inhomogeneities. Thus these media can be useful in modeling the propagation of waves in inhomogeneous media. An example supporting the utility of modeling applications is presented.

78-1574

Harmonic Wave Propagation in a Periodically Layered, Infinite Elastic Body: Antiplane Strain

T.J. Delph, G. Herrmann, and R.K. Kaul
Oak Ridge National Lab., Oak Ridge, TN, J. Appl. Mech., Trans. ASME, 45 (2), pp 343-349 (June 1978) 10 figs, 10 refs

Key Words: Wave propagation, Elastic media

The propagation of horizontally polarized shear waves through a periodically layered elastic medium is analyzed. The dispersion equation is obtained by using Floquet's theory and is shown to define a surface in frequency-wave number space. The important features of the surface are the passing and stopping bands, where harmonic waves are propagated or attenuated, respectively. Other features of the spectrum, such as uncoupling at the ends of the Brillouin zones, conical points, and asymptotic values at short wavelengths, are also examined.

FLUID

(Also see Nos. 1522, 1618, 1684, 1691)

78-1575

Variational Formulations of Hydrocapillary Vibration Problems. Results Obtained with the Finite Element Method

H. Morand and R. Hayon
Office National d'Etudes et de Recherches Aerospatiales, Paris, France, In: ESA Attitude Control of Space Vehicles: Technol. and Dyn. Probl. Assoc. with the Presence of Liquids, pp 105-119 (Dec 1977) (In French, English summary)
N78-20188

Key Words: Finite element technique, Fluid-induced excitation

Various symmetric mixed variational formulations of the hydro-capillary vibrations problem are established. They lead directly to a numerical treatment by a mixed finite element method. The formulations presented are quite capable of taking into account the various kinematic conditions imposed at the meniscus edge. Numerical results are shown on test configurations for static and dynamic configurations. The results obtained show the validity and the efficiency of the proposed methods.

78-1576

Intelsat 4 In-Orbit Liquid Slosh Tests and Problems in the Theoretical Analysis of the Data

V.J. Slabinski
Communications Satellite Corp., Washington, D.C., In: ESA Attitude Control of Space Vehicles: Technol. and Dyn. Probl. Assoc. with the Presence of Liquids, pp 87-102 (Dec 1977)
N78-20187

Key Words: Spacecraft, Sloshing, Liquid propellants, Fluid-filled containers, Fluid-induced excitation

Intelsat 4 liquid slosh tests are presented. Each Intelsat 4 dual spin spacecraft has four conisphere propellant tanks containing liquid hydrazine mounted on the spinning rotor section. The destabilizing effect of the liquid on attitude-nutation stability was determined from an extensive series of in-orbit tests. The liquid slosh driving frequency ratio (rotor nutation frequency/rotor spin rate) was varied over the range from 0.58 to 0.70 for the tests by rotating the spacecraft antenna platform at different rates in inertial space. A rotor mounted accelerometer sensed the spacecraft nutation. The observed time constant for the nutation angle increase or decrease was corrected for the stabilizing contribution of the platform mounted pendulum dampers to yield the net destabilizing dedamping contribution from the liquid slosh.

78-1577

Two Congruence Theorems for the Vibrations of Liquids Coupled with Structures

H. Morand
Office National d'Etudes et de Recherches Aerospatiales, Paris, France, In: ESA Attitude Control of Space Vehicles: Technol. and Dyn. Probl. Assoc. with the Presence of Liquids, pp 121-130 (Dec 1977) (In French, English summary)
N78-20189

Key Words: Fluid-filled containers, Fluid induced excitation, Spacecraft, Sloshing, Liquid propellants

Congruence theorems for the vibration of a liquid under capillary tension and uniform acceleration contained in a rigid (satellite) tank and for the hydroelastic vibrations of a flexible tank containing a liquid were derived.

78-1578

Theoretical and Experimental Study of the Dynamics of a Spinning Satellite with Toroidal Tank

M. Dokhac, J. Fave, J.P. Guibert, and J.L. Marce
Office National d'Etudes et de Recherches Aerospatiales, Paris, France, In: ESA Attitude Control of Space Vehicles: Technol. and Dyn. Probl. Assoc. with the Presence of Liquids, pp 63-76 (Dec 1977) (In French)
N78-20185

Key Words: Spacecraft, Sloshing, Liquid propellants, Fluid-filled containers, Fluid-induced excitation

The stability of the nutation motion of a satellite with a toroidal tank containing a liquid, coaxial with the spinning satellite, was studied by a modal representation of the liquid motions. These comprise free surface motions and internal motions. The energy dissipation is accounted for by means of a laminar boundary layer associated with each mode. The instability zone obtained by retaining the first modes agrees well with the limit defined by the Rumyantsev criterion.

78-1579

The Dynamic Response of Gravity Platforms

R. Dungar and P.J.L. Eldred
Dept. of Civil Engrg., Univ. of Bristol, UK, Intl. J. Earthquake Engr. Struc. Dynam., 6 (2), pp 123-128 (Mar/Apr 1978) 13 figs, 2 tables, 20 refs

Key Words: Off-shore structures, Water waves, Fluid-induced excitation, Interaction: structure-foundation, Interaction: structure-fluid

Gravity platforms, together with associated regions of foundation and fluid, are idealized using the finite element method. Radiation of wave energy away from the platform region is modeled by appropriate damping applied to the boundary of the foundation mesh. Response results, due to sinusoidally applied forces, are calculated for seven platform-foundation configurations. Of particular interest are those results for various assumed foundation conditions, including the presence of stiff soil layers. The response of these platforms due to North Sea storm conditions is also estimated. It is concluded that a simple static analysis of the platform-foundation system does not necessarily give an accurate prediction of the response under extreme loading conditions.

78-1580

Coupled Hydrodynamic Response of Concrete Gravity Dams Using Finite and Infinite Elements

S.S. Saini, P. Bettess, and O.C. Zienkiewicz

Water Resources Dev. Training Center, Univ. of Roorkee, Roorkee, India, Intl. J. Earthquake Engr. Struc. Dynam., 6 (4), pp 363-374 (July/Aug 1978) 8 figs, 2 tables, 12 refs

Key Words: Dams, Concretes, Hydrodynamic excitation, Finite element technique, Damping effects

This paper presents the application of the finite element method for analyzing the two-dimensional response of reservoir-dam systems subjected to horizontal ground motion. The interaction between the dam and the reservoir as well as the compressibility of water has been taken into account. The complete system has been considered to be composed of two substructures, namely the reservoir and the dam. To take into account the large extent of the reservoir, it has been idealized using specially developed infinite elements coupled with standard finite elements while the dam is represented using finite elements alone. Structural damping of the dam and radiation damping in the fluid phase have been accounted for in the analysis.

SOIL

78-1581

Parameter Estimation from Non-normal Modes of Soil-Structure Interaction

J.G. Beliveau

Dept. of Civil Engrg., Universite de Sherbrooke, Sherbrooke, Quebec, Canada, J. Optim. Theory and Appl., 23 (1), pp 41-51 (Sept 1977) 3 figs, 5 tables, 9 refs

Key Words: Interaction: soil-structure, Parameter identification technique

The damping in soil-structure interaction problems is known to be not proportional; thus, the mode shapes are not normal. Parameters may be estimated, however, including those associated with damping, if use is made of phase angle information. Two examples of this interaction are considered. In the first example, a one-story relatively flexible building, the interaction coefficients are estimated. Soil parameters are identified in a second example of a stiff structure modeling a nuclear reactor containment vessel. Modal information is used in both instances.

78-1582

Empirical Shear Wave Velocity Equations in Terms of Characteristic Soil Indexes

Y. Ohta and N. Goto

Dept. of Architectural Engrg., Hokkaido Univ., Sapporo, Japan, Intl. J. Earthquake Engr. Struc. Dynam., 6 (2), pp 167-187 (Mar/Apr 1978) 7 figs, 2 tables, 24 refs

Key Words: Secondary waves, Wave propagation, Soils

An investigation to systematize empirical equations for the shear wave velocity of soils was made in terms of four characteristic indices. The adopted indices are the N-value of the Standard Penetration Test, depth where the soil is situated, geological epoch and soil type. As some of these indices are variates belonging to interval scales while others belong to nominal or ordinal scales, the technique known as a multivariate analysis cannot be employed. A new approach to the theory of quantification, after C. Hayashi, was introduced and developed for solving this difficulty.

78-1583

On the Interaction of Rayleigh Surface Waves with Structures

I.C. Simpson

Dept. of Appl. Mathematics, Queen Mary College, Mile End Road, London, UK, Intl. J. Earthquake Engr. Struc. Dynam., 6 (3), pp 247-263 (May/June 1978) 11 figs, 2 tables, 26 refs

Key Words: Interaction: soil-structure, Seismic excitation

A two-dimensional soil-structure interaction analysis is carried out for transient Rayleigh surface waves that are incident on a structure. The structure is modeled by a three-degree of freedom rigid basemat to which is attached a flexible superstructure, modeled by a single mass-spring system. The structural responses to a given Rayleigh wave train are compared with those that would have been obtained if the free-field acceleration-time history had been applied as a normally incident body wave.

78-1584

An Improved Fluid Superelement for the Coupled Solid-Fluid-Surface Wave Dynamic Interaction Problem

J.J. Dubois and A.L. De Rouvray

Engrg. System International, 20 rue Saarinen, 94150 Rungis-Silic, France, Intl. J. Earthquake Engr. Struc. Dynam., 6 (3), pp 235-245 (May/June 1978) 5 figs, 13 refs

Key Words: Interaction: solid-fluid, Fluid-induced excitation, Seismic excitation, Finite element technique

The dynamic solid-fluid-surface wave interaction problem can be solved with known finite element solutions. However, these solutions are complicated by the unsymmetric nature of the matrix equation to be solved. This paper shows how the numerical problem can be simplified by symmetrization, without loss of physical generality, using specialized Lagrange co-ordinates for the fluid free surface wave, and by introducing a Lagrange multiplier representing a generalized fluid pressure. With these improvements, solid-fluid-surface wave analysis capabilities can easily be added to most finite element structural analysis programs. Numerical examples of the performance of the improved formulation are given for earthquake analysis.

VISCOELASTIC

78-1585

Dynamic Stiffness Matrices for Homogeneous Viscoelastic Halfplanes

G. Dasgupta and A.K. Chopra
Earthquake Engrg. Res. Center, California Univ., Richmond, CA., Rept. No. UCB/EERC-77/26, 125 pp (Nov 1977)
PB-279 654/8GA

Key Words: Dynamic stiffness, Half-plane, Viscoelastic properties

Analytical expressions and numerical results are presented for the complex-valued, dynamic (frequency dependent), flexibility influence coefficients for a homogeneous, isotropic, linearly viscoelastic half space in plane strain or generalized plane stress. These influence coefficients, defined for uniformly spaced nodal points at the surface of the half space, are obtained from solutions of two boundary value problems, associated with harmonically time-varying stresses uniformly distributed between two adjacent nodal points. Numerical values for these coefficients are presented for a viscoelastic half space of constant hysteretic material. A method is developed to determine from these results the dynamic stiffness matrix, associated with the nodal points at the base of a surface supported structure, for the half space.

EXPERIMENTATION

BALANCING

78-1586

High Speed Rotor Balancing

W.D. Pilkey
Dept. of Mech. Engrg., Univ. of Virginia, Charlottesville, VA, Rept. No. AD-A050793; UVA/525037/MAE78/101, 12 pp (Feb 1977)
N78-22379

Key Words: Rotor-bearing systems, Balancing techniques, Optimization

This report summarizes the accomplishments of a study exploring new methods for balancing, analyzing and designing flexible rotating shafts. It is assumed that the balancing problem is an identification/optimization problem. Emphasis is given to computational optimization formulations. In addition to balancing techniques, an optimal design procedure for rotor bearing systems is proposed. Also, modal and direct integration transient analysis methods are developed. Finally, a numerically stable analysis approach is formulated and implemented.

78-1587

Balancing Techniques for High-Speed Flexible Rotors

A.J. Smalley
Mechanical Technology, Inc., Latham, NY, Rept. No. NASA-CR-2975; MTI-77TR2, 129 pp (Apr 1978)
N78-20514

Key Words: Flexible rotors, Balancing techniques

Ideal and non-ideal conditions for multiplane balancing are addressed. Methodology and procedures for identifying optimum balancing configurations and for assessing, quantitatively, the penalties associated with non-optimum configurations were developed and demonstrated. The problems introduced when vibration sensors are supported on flexible mounts were assessed experimentally, and the effects of flexural asymmetry in the rotor on balancing were investigated. A general purpose method for predicting the threshold of instability of an asymmetric rotor was developed, and its predictions are compared with measurements under different degrees of asymmetry.

DIAGNOSTICS

78-1588

The Application of a Time-Domain Deconvolution Technique for Identification of Experimental Acoustic-Emission Signals

J.R. Houghton, M.A. Townsend, and P.F. Packman

Dept. of Mech. Engrg., Tennessee Tech. Univ., Cookeville, TN 38501, Exptl. Mech., 18 (6), pp 233-239 (June 1978) 10 figs, 6 refs
Sponsored by Marshall Space Flight Center, NASA

Key Words: Signature analysis, Diagnostic techniques

A method is presented for the signature analysis of pulses by reconstructing in the time domain the shape of the pulse prior to its passing through the measurement system. This deconvolution technique is first evaluated using an idealized system and analytical pulse models and is shown to provide improved results. An experimental situation is then treated; system-component models are developed for the digitizer, tape recorder, filter, transducer and mechanical structure. To accommodate both calibration results and manufacturer's data, and to provide stable mathematical models entails considerable effort: some 30 parameters must be identified to model this system -- which is still a substantial approximation -- albeit of very high order. Experimental pulses generated by a ball drop, spark discharge and a tearing crack are then deconvoluted 'back through' the system as modeled, using this technique. These results are compared and indicate that consistent shapes may be expected from a given type of source and that some sources can be identified with greater clarity using the deconvolution approach.

78-1589
Attacking Structural Vibration Through Spectrum Analysis
G. Heimbigner
Hewlett-Packard Co., Loveland, CO, Mach. Des., 50 (13), pp 108-113 (June 8, 1978)

Key Words: Vibration control, Spectrum analysis, Diagnostic techniques

Some types of vibration are stopped by the addition of mass or sound deadeners; other types are eliminated only by an increase in structural stiffness. Knowing which remedy to use -- or whether an entirely new strategy is called for -- demands information that only a spectrum analyzer can provide.

78-1590
Solving the Problem of Vertical Pump Vibration
R.J. Meyer
Industrial Pump Div., Allis-Chalmers Corp., Noise Control. Vib. Isolation, pp 184-190 (May 1978) 6 figs

Key Words: Diagnostic techniques, Pumps, Resonant response

A systematic approach for solving resonant vibration problems of vertical pumps is described.

INSTRUMENTATION

78-1591
New Method Predicts Startup Torque. Part 2: Field Measurements and Abnormal Motor Conditions
G.K. Mruk, J.D. Halloran, and R.M. Kolodziej
Joy Mfg. Co., Buffalo, NY, Hydrocarbon Processing, 57 (5), pp 229-234 (May 1978) 14 figs, 1 table, 11 refs

Key Words: Torque, Compressors, Measuring instruments

In the startup of a synchronous motor driven compressor system, a pulsating torque of twice motor slip frequency is created in the motor air gap which excites resonances of the system. Instantaneous magnitudes of excitation torque and its consequent torsional shaft stress are two values that should be measured at field installation. These can be used to verify the analytical design, ensure safe operation and detect any motor starting malfunctions.

78-1592
Telemetry for Rotating Measurements on Turbomachinery
A. Adler
Acurex Corp., Mountain View, CA, ASME Paper No. 78-GT-105

Key Words: Measuring instruments, Turbomachinery, Rotors, Mechanical telemetry

In the past decade, the use of shaft-mounted radio telemetry systems, for measurements on the rotating components of turbomachines, has grown to maturity. This applications-oriented paper covers the following topics: What is telemetry? advantages and limitations; choosing between telemetry and slip-rings; designing a telemetry installation; conducting the engine test, and forthcoming developments in telemetry.

SCALING AND MODELING

78-1593
Scaling Problems in Dynamic Tests of Aircraft-Like Configurations

L.E. Ericson and J.P. Reding
Lockheed Missiles and Space Co., Sunnyvale, CA., In: AGARD Unsteady Aerodyn., 11 pp (Feb 1978)
N78-22057

Key Words: Scaling, Aircraft, Spacecraft, Dynamic tests

To extrapolate from subscale wind tunnel tests to full scale flight is a well recognized problem. In the case of dynamic tests it may not be possible to simulate flight conditions at subscale Reynolds number. This is illustrated by example from two dimensional dynamic stall tests at low speeds and dynamic tests of fully three dimensional configurations at transonic speeds, such as the space shuttle orbiter.

TECHNIQUES

(Also see Nos. 1534, 1557, 1602)

78-1594

An Improved Approach to Man-Made Noise Measurement Techniques

F.H. Tabor
IIT Res. Inst., Annapolis, MD, SAE Paper No. 780-659, 8 pp, 3 figs, 2 tables, 1 ref

Key Words: Noise measurement, Measurement techniques

Nonpredictable responses to certain kinds of noise have been revealed as a result of past analyses of receiver noise responses. It seemed that certain types of noise were not susceptible of classification as either white Gaussian or impulsive, but rather that some intermediate classification was necessary. The development of an improved measurement technique of man-made noise sources was then undertaken. These techniques would then be applied in the measurement of noise radiated by several commonly found man-made sources. The measurement technique developed consists of displaying the noise power spectra in incremented bandwidths on a spectrum analyzer. Ten different sources were measured and the bandwidth factors recorded.

78-1595

Prediction of Dynamometer Power Absorption to Simulate Light-Duty Vehicle Road Load

G.D. Thompson
U.S. Environmental Protection Agency, SAE Paper No. 780617, 28 pp, 6 figs, 18 tables, 17 refs

Key Words: Measurement techniques, Dynamometers

When vehicle exhaust emission tests or vehicle fuel consumption measurements are performed on a chassis dynamometer, the dynamometer is usually adjusted to simulate the road experience of the vehicle. In this study, road load versus speed data were obtained from 64 light-duty vehicles. Dynamometer power absorption settings to simulate the measured road loads are computed. These dynamometer settings are regressed against vehicle frontal area and vehicle inertia weight. It is concluded that the dynamometer load settings are most accurately predicted on the basis of the vehicle frontal area. The frontal area based prediction system is then improved by separating vehicles into different classes and by including estimations of the effects of the vehicle protuberances.

78-1596

A Computer-Controlled System for Fatigue Testing Under Simulated Service Loading

H. Morr and A. Berkovits
Dept. of Aeronautical Engrg., Technion-Israel Inst. of Tech., Haifa, Israel, Israel J. Tech., 15 (4/5), pp 318-325 (1977) 6 figs, 5 tables, 6 refs

Key Words: Fatigue tests, Testing techniques, Computer-aided techniques

Development of computer software for programming simulated service loads in the fatigue testing system for aircraft structures laboratory is described. The fatigue testing system is suitable for performing fatigue tests on aircraft, ship, and land-transport structures. Two basic computer programs were developed for controlling fatigue tests, both programs being applicable to a wide range of specific load histories. The Block Program permits the test engineer to choose a deterministic block of load sequences, consisting of an arbitrary set of maximum and minimum load pairs. Each such pair constitutes a load-cycle which may be applied from one to any number of times.

78-1597

Evaluation of Flaw Indications by Ultrasonic Pulse Amplitude and Phase Spectroscopy

E. Nabel
Oak Ridge National Lab., Oak Ridge, TN, Rept. No. ORNL-tr-4355, 12 pp (1977)
N78-21484

Key Words: Nondestructive testing, Spectrum analysis

In nondestructive testing with ultrasound there were no criteria which made it possible to answer questions as to nature, size, and orientation in a sufficient unambiguous manner. The echo amplitude which was used in many cases as the sole measure for evaluation depends on orientation and size of the reflector, as well as on the frequency and the bandwidth of the transducer. In practice these dependencies cannot be taken into account. The results described were found during research on methods for unambiguous evaluation of echoes by spectrum analysis according to amplitude and phase and by deconvolution of the signals.

COMPONENTS

ABSORBERS

78-1598

Proceedings of the Workshop on Acoustic Attenuation Materials Systems

National Materials Advisory Board (Nas-Nae), Washington, D.C., Rept. No. NMAB-339, 152 pp (1978) AD-A053 337/2GA

Key Words: Acoustic absorption, Absorbers (materials)

The choice and use of materials for acoustical attenuation is an important technical problem as well as of great interest for improving comfort and working efficiency. Although the major effort in this field is at ambient conditions and in the audio frequency range, there are important applications that involve widely varying pressures, temperatures, and frequencies along with other requirements peculiar to the particular use. Among current problems in the control of acoustic energy are those associated with such diverse applications as ultrasonic devices, space vehicles, and deep-diving oceanographic vehicles. Each of these, of course, may also have other quite different requirements of the acoustical materials in such properties as density, pressure responses, and flammability.

SHAFTS

78-1599

Influence of Unequal Pedestal Stiffness on the Instability Regions of a Rotating Asymmetric Shaft

H. Ota and K. Mizutani

Dept. of Mech. Engrg., Nagoya Univ., Furo-cho, Chikusa-ku, Nagoya, Japan, J. Appl. Mech., Trans. ASME, 45 (2), pp 400-408 (June 1978) 7 figs, 1 table, 12 refs

Key Words: Shafts, Asymmetry, Foundations, Variable material properties

This paper treats unstable vibrations of a rotating asymmetric shaft supported by upper and lower flexible bearing pedestals each of which has a directional inequality in stiffness and a concentrated mass. The position, width and number of the instability regions and a dynamic behavior of the shaft are analytically obtained by approximation. As a result, it is determined simply by one parameter that each unstable region which is caused only by asymmetry of the rotating shaft is split up into several parts (one, two, three, or four regions) by the directional stiffness inequality of bearing pedestals. Instability regions derived from approximation were found to agree well with those obtained by analog computer.

BEAMS, STRINGS, RODS, BARS

(Also see No. 1569)

78-1600

Pseudo-Coupled Bending-Torsion Vibrations of Beams Under Lateral Parametric Excitation

E. Dokumaci

Faculty of Mech. Engrg., Ege Univ., Izmir, Turkey, J. Sound Vib., 58 (2), pp 233-238 (May 22, 1978) 4 figs, 6 refs

Key Words: Beams, Parametric excitation, Flexural vibration, Torsional vibration

This paper presents a theoretical and experimental study of the dynamic stability of straight uniform beams under lateral parametric excitation. The calculation of the boundaries of stability is based on the finitization of the problem by means of the Rayleigh-Ritz method and application of the small parameter stability criterion to the resulting periodic linear system. An experimental study was carried out on a cantilever beam excited by base motion acting in the largest plane of rigidity of the beam. A close correlation has been established between the calculated and measured boundaries of instability by taking into account the nonlinear damping characteristics exhibited by the beams tested.

78-1601

Shock Analysis of Tubular Viscoplastic Beams

S.G. Gatchel and V.H. Neubert

Dept. of Engrg. Science and Mechanics, Pennsylvania State Univ., University Park, PA, Rept. No. 2 (Final), 112 pp (July 1977)
AD-A053 185/5GA

Key Words: Cantilever beams, Viscoplastic properties, Piping, Ground shock, Computer programs

An analytical method is outlined, and a related computer program Viscoplastic Beam Analysis (VPBA) is discussed, for prediction of response of a viscoplastic cantilever beam to ground shock. Some beams, which could be built using standard piping, are designed and analyzed using inputs typical of those on the floating shock barge.

BEARINGS

78-1602

A New Technology for Monitoring Bearing Performance

Des. News., 34 (14), pp 42, 44, 47-48 (July 17, 1978) 9 figs

Key Words: Bearings, Testing techniques, Test instrumentation

A study of bearing performance by means of a recently-developed system which -- with a single fiber optic transducer -- has the capability of sensing the dynamic deflections of ball bearings as well as inner and outer raceway faults and surface discontinuities, such as cracks is described.

78-1603

Varying Compliance Vibrations of Rolling Bearings

C.S. Sunnersjo

Dept. of Mech. Engrg., Univ. of Aston, Gosta Green, Birmingham B4 7ET, UK, J. Sound Vib., 58 (3), pp 363-373 (June 8, 1978) 10 figs, 7 refs

Key Words: Roller bearings, Parametric vibration

The most fundamental cause of noise and unsteady running of rolling bearings is the so-called varying compliance vibrations. These are parametrically excited vibrations that occur irrespective of the quality and accuracy of the bearing. Varying compliance of the bearing assembly can give rise to both radial and axial displacements of a shaft supported by rolling bearings. In this study, however, attention is focused on radial vibrations of radially loaded bearings having a positive radial clearance. Previous studies of this phenomena are quasi-static in approach -- the inclusion of inertia forces reveals characteristics not previously recognized. Examples of theoretical solutions obtained through digital simulation are presented and comparisons with experimentally obtained results are made.

78-1604

Active Magnetic Bearings in Turbo-Equipment

H. Habermann and G. Liard

Ball Bearing J., (195), pp 16-20 (May 1978) 6 figs

Key Words: Magnetic bearings, Damping effects

The earliest industrial use of active magnetic bearings has been in a turbo-driven vacuum pump. The pump is unique with regard to capacity and noiseless operation. Magnetic bearing characteristics are described.

78-1605

A Dynamic Method of Determining the Stiffness and Cross Axis Stability of a Repulsion Magnetic Bearing

R.N.A. Plimmer

Royal Aircraft Establishment, Farnborough, UK, Rept. No. RAE-TR-77122, DRIC-BR-60409, 21 pp (Aug 1977)

AD-A052 092/4GA

Key Words: Magnetic bearings, Vibration frequencies, Vibration measurement

Magnet bearing support systems are becoming of increasing interest in satellite and other engineering projects. In order to design such systems a knowledge of the bearing stiffness is required. This report analyzes the dynamics of a repulsive type magnet bearing and proposes a simple pendulum experiment to determine the radial stiffness by measuring the vibration frequency.

BLADES

78-1606

Vibrations of a Helicopter Rotor Blade Using Finite Element-Unconstrained Variational Formulations

J.J. Wu and C.N. Shen

Benet Weapons Lab., Army Armament Res. and Dev. Command, Watervliet, NY, Rept. No. ARLCB-TR-77038, AD-E400 118, 31 pp (Sept 1977)

AD-A052 670/7GA

Key Words: Rotary wings, Helicopter rotors, Finite element technique

In the past several years, a numerical method has been developed which is a generalized Rayleigh-Ritz - finite element discretization using the combined concept of Lagrange multipliers and adjoint variables. This approach enables one to deal with problems associated with nonconservative forces, coupling effects and all types of boundary conditions in a routine fashion; and it appears promising in solving the vibration and dynamic stability problems associated with the complicated equations of a helicopter rotor blade. This paper presents the first application of the general method of the vibration problem of such a rotor blade.

CYLINDERS

(See No. 1528)

GEARS

78-1607

Vibration of Helical Gears. Part 1. Theoretical Analysis

S. Kiyono, T. Aida, and Y. Fujii

Faculty of Engrg., Tohoku Univ., Sendai, Japan,
Bull. JSME, 21 (155), pp 915-922 (May 1978) 11 figs, 3 tables, 3 refs

Key Words: Helical gears, Coupled response

A coupled vibration system of a pair of helical gears and gear-carrying shafts is analyzed theoretically. The coupled vibration has four-directional components, which are torsional, lateral, longitudinal vibrations and rotational one about a certain diameter of a gear. In the analyses three pairs of helical gears of different helix angles are compared with a pair of spur gears.

78-1608

Vibration of Helical Gears. Part 2. Experimental Investigation

S. Kiyono, T. Aida, and Y. Fujii

Faculty of Engrg., Tohoku Univ., Sendai, Japan,
Bull. JSME, 21 (155), pp 923-930 (May 1978) 15 figs, 3 tables, 10 refs

Key Words: Helical gears, Coupled response, Experimental data

Dynamic strain and accelerations of three-directional vibrations of helical gears are measured and their natural frequencies, modes and exciting force are discussed in comparison with those of spur gears.

PANELS

78-1609

Vibration os Orthogonally Stiffened Panels

N.F. Madsen

Dept. of Ocean Engrg., The Tech. Univ. of Denmark, Lyngby, Denmark,
J. Ship Res., 22 (2), pp 100-109 (June 1978) 12 figs, 9 refs

Sponsored by the Danish Council for Scientific Tech. Research

Key Words: Stiffened panels, Natural frequencies, Mode shapes, Numerical analysis

A general numerical method for the determination of natural frequencies and modes of vibration for orthogonally stiffened panels is presented. The panel is considered as an assembly of prismatic beams and plate strips rigidly connected along their longitudinal edges and transversely stiffened by beams of varying cross section. The modes of vibration are approximated by linear combinations of the analytically calculated modes of vibration for the prismatic panel, resulting from neglecting the transverse stiffening and assuming simple end supports. For the transverse stiffening, the effects of shear deflection, axial deformation, and St. Venant torsion are taken into account. As a practical example, the natural frequencies of a deep girder in a tanker have been calculated.

PIPES AND TUBES

78-1610

Seismic Response Analysis of Above-Ground Pipelines

G.H. Powell

Univ. of California, Berkeley, CA,
Intl. J. Earthquake Engr. Struc. Dynam., 6 (2), pp 157-165 (Mar/Apr 1978) 4 figs, 1 table, 4 refs

Key Words: Pipelines, Seismic response, Computer programs

A procedure for computing the seismic response of above-ground, cross-country pipelines is described. The procedure accounts for the effects of initial static loads, slipping of the pipe on its supports and out-of-phase ground motions at different points along the pipe. The idealization, assumptions and theory are described, and an example illustrating the influence of several parameters on the response is presented.

PLATES AND SHELLS

(Also see Nos. 1542, 1550)

78-1611

A Finite-Element Method Applied to the Vibration of Submerged Plates

M.S. Marcus
David W. Taylor Naval Ship Res. and Dev. Center, Bethesda, MD, J. Ship Res., 22 (2), pp 94-99 (June 1978) 8 figs, 1 table, 14 refs
Sponsored by David W. Taylor Naval Ship Res. and Dev. Center

Key Words: Cantilever plates, Submerged structures, Interaction: structure-fluid, Free vibration, NASTRAN (computer program), Computer programs

A finite-element approach is used to simulate the free vibration of submerged cantilever plates. The method explicitly models an acoustic fluid with pressure as the basic fluid unknown. Only standard capabilities of structural analysis computer codes such as NASTRAN are required for implementation. The computations performed take into account liquid free surface and partial submergence effects. The numerical results obtained compare favorably with experimentally measured frequencies of vibrating plates. Modeling requirements are discussed. Application areas include the vibration in water of rudders, propeller blades, and other ship appendages.

78-1612

Stability of Cantilever Plates Subjected to Biaxial Subtangential Loading

M. Farshad
Dept. of Civil Engrg., Pahlavi Univ., Shiraz, Iran, J. Sound Vib., 58 (4), pp 555-561 (June 22, 1978) 5 figs, 15 refs

Key Words: Cantilever plates, Dynamic stability

The stability of cantilever plates which, mathematically, comprises a non-self-adjoint problem is investigated. It is assumed that the plate is acted upon by a subtangential biaxial edge load embodying the dead loading and the follower type loading as its limiting states. The scheme of modal expansions, containing the constrained rigid modes, together with Galerkin's method is employed and the stability of the plate in terms of subtangency and load parameters is analyzed. As an example the kinetic stability analysis of a square cantilever plate is carried out in detail.

78-1613

On the Analysis of Large Amplitude Vibrations of Non-Uniform Rectangular Plates

M.M. Banerjee
Dept. of Mathematics, Ananda Chandra College, Jalpaiguri 735101, India, J. Sound Vib., 58 (4), pp 545-553 (June 22, 1978) 3 figs, 1 table, 15 refs

Key Words: Rectangular plates, Large amplitudes, Nonlinear response

An analysis of the large amplitude vibrations of non-uniform rectangular plates is presented. The method is based on Berger's assumption of neglecting the second invariant of the middle surface strain in the expression corresponding to the total potential energy of the system, in conjunction with a Galerkin procedure.

78-1614

Random Vibration of an Elastically Supported Circular Plate with an Elastically Restrained Edge and an Initial Tension

S. Chonan
Dept. of Mech. Engrg., Tohoku Univ., Sendai, Japan, J. Sound Vib., 58 (3), pp 443-454 (June 8, 1978) 10 figs, 6 refs

Key Words: Circular plates, Elastic foundations, Random response

This paper deals with the problem of the random vibration of an elastically supported circular plate with an elastically restrained edge and an initial radial tension. The random excitation is taken to be a distribution of spatially uncorrelated random forces. Analytical expressions for the mean square displacement and moment are derived by using the orthogonality property of the mode functions. Numerical results are then given for a range of parameters.

78-1615

Dynamic Response of Circular Plates Resting on Viscoelastic Half Space

Y.J. Lin
Hughes Aircraft Co., Culver City, CA., J. Appl. Mech., Trans. ASME, 45 (2), pp 379-384 (June 1978) 7 figs, 12 refs

Key Words: Circular plates, Viscoelastic properties, Half-space

Dynamic responses of circular thin plates resting on viscoelastic half space subject to harmonic vertical and rocking excitations are studied. The analysis is based on the assumption that the contact between the plate and the surface of the half space is frictionless. This dynamic mixed boundary-value problem leads to sets of dual integral equations which are reduced to Fredholm integral equations of the second kind and solved by numerical procedures. The numerical

results show that the rocking impedance function is independent of the plate flexibility, but the vertical excitation is not.

78-1616

Buckling and Vibrations of Circular Plates of Variable Thickness

U.S. Gupta and R. Lal
Dept. of Mathematics, Univ. of Roorkee, Roorkee, India, J. Sound Vib., 58 (4), pp 501-507 (June 22, 1978) 5 figs, 1 table, 13 refs

Key Words: Circular plates, Variable cross section, Winkler foundations

Axisymmetric vibrations of a circular plate of linearly varying thickness under the action of an hydrostatic in-plane force and resting on elastic foundation of Winkler type are discussed on the basis of the classical theory of plates. The fourth order linear differential equation governing the transverse motion is solved by Frobenius' method. Frequency parameters of clamped as well as simply supported plates for the first three modes of vibration are computed for various values of the taper parameter, the foundation modulus and the in-plane force. Transverse displacements and moments have also been computed.

78-1617

Dynamic Instability Analysis of Axisymmetric Shells by Finite Element Method with Convected Coordinates

B.J. Hsieh
Components Tech. Div., Argonne National Lab., IL, Rept. No. CONF-770807-34, 12 pp (1977)
N78-21505

Key Words: Shells of revolution, Nuclear reactor components, Dynamic stability, Finite element technique

The instability of axisymmetric shells has been used in engineering fields as a safety device such as the rupture discs used in the LMFBR (Liquid Metal Fast Breeder Reactor) design to relieve the excessive pressure caused by the water and sodium reaction when there is a leak in the piping system. Hence, the analysis of the instability of shells under time varying loading is becoming more and more important.

78-1618

Dynamics of an Initially Stressed Fluid-Immersed Cylindrical Shell

H. Reismann and G.J. Meyers
State Univ. of New York, Buffalo, NY, J. Hydronautics, 12 (3), pp 118-121 (July 1978) 4 figs, 12 refs

Key Words: Cylindrical shells, Fluid-induced excitation, Submerged structures

This investigation considers the axisymmetric dynamic response of an initially stressed elastic cylindrical shell submerged in a fluid. Differential equations of motion and dispersion relations for the fluid-shell system are presented. A transient solution is found for the motion of an unbounded shell excited by an impulsively applied radially directed ring loading.

78-1619

Hardening Technology Studies. Volume IV-C. Response of Reentry Vehicle-Type Shells to Blast Loads

H.E. Lindberg, D.L. Anderson, R.D. Firth, and L.V. Parker
Lockheed Missiles and Space Co., Sunnyvale, CA, Rept. No. LMSC-B130200-Vol-4-C, 324 pp (Sept 30, 1965)
AD-477 394/1GA

Key Words: Cylindrical shells, Conical shells, Reentry vehicles, Blast response

The response of re-entry vehicle-type shells to blast loads is investigated and is described in terms of surface loads on the vehicle. Extensive data on both surface pressures and structural response of cylindrical and conical shells are presented. Peak pressure and impulse are identified as the important load characteristics which determine structural response and critical loads are presented in these terms. A theoretical description of dynamic buckling of cylindrical shells subjected to transient surface pressures is given to explain observed modes of failure and to predict critical loads for buckling over a wide range of load and structural parameters.

78-1620

Dynamic Response of a Pressurized Plane Strain Cylinder Under Impulsive Distributed Loading Using Finite Elements

G.E. Weeks and T.L. Cost
Dept. of Aerospace Engrg., Univ. of Alabama, University, AL 35486, Mech. Res. Comm., 5 (2), pp 65-71 (1978) 3 figs, 9 refs
Sponsored by the U.S. Army Ballistic Res. Labs., Aberdeen, MD

Key Words: Cylindrical shells, Blast response, Finite element technique

An investigation of the stiffening effect of static pressure on plane strain cylindrical shells subjected to dynamic distributed blast loads was conducted. The finite element method is used to reduce the global balance principle to a set of nonlinear, coupled, ordinary differential equations involving the time-dependent nodal point displacements. The Newmark constant-average-acceleration operator is used to numerically integrate the time-dependent differential equations to obtain the shell transient dynamic response. A parameter study was conducted to determine the sensitivity of effective shell stiffness on shell geometry and static pressure levels.

78-1621

Dynamic Stability of Circular Cylindrical Shells Under Periodic Compressive Forces

K. Nagai and N. Yamaki

College of Tech., Gunma Univ., Kiryu, Japan, J. Sound Vib., 58 (3), pp 425-441 (June 8, 1978) 9 figs, 11 refs

Key Words: Cylindrical shells, Flexural vibration, Periodic excitation

Based on the Donnell equations modified with the transverse inertia force, the dynamic stability of circular cylindrical shells under both static and periodic compressive forces is theoretically analyzed under four different boundary conditions, with the effect of the axisymmetric unperturbed bending vibration taken into consideration. The problem is first reduced to that of a finite degree-of-freedom system with the Galerkin procedure, the stability of which is examined by using Hsu's method. Calculations are carried out for typical cases and the instability regions of the principal, secondary and combination parametric resonances are determined for the frequency range covering up to several times the lowest natural frequency. It is found, among others, that the effect of the unperturbed motion is quite significant for shells with moderate length while that of the longitudinal resonance is generally negligible for thin shells.

78-1622

A High Precision Ring Element for Vibrations of Laminated Shells

K.N. Shivakumar and A.V. Krishna Murty

Dept. of Aeronautical Engrg., Indian Inst. of Science, Bangalore-560012, India, J. Sound Vib., 58 (3), pp 311-318 (June 8, 1978) 2 figs, 4 tables, 9 refs

Key Words: Natural frequencies, Cylindrical shells, Conical shells, Finite element technique

This paper presents a sixteen degrees of freedom ring element, for natural vibration analysis of laminated cylindrical or conical shells. The successful performance of this element has been demonstrated by typical numerical studies on cylindrical and conical, isotropic and laminated composite shells.

78-1623

Dynamic Response of Missile Structures to Impulsive Loads Caused by Nuclear Effects Blowoff

T.L. Cost

Athena Engrg. Co., Northport, AL, Rept. No. AEC-TR-76-01, 45 pp (June 1976)

AD-A052 999/0GA

Key Words: Missiles, Cylindrical shells, Nuclear weapons effects, Blast effects, Computer programs

Two dynamic structural analysis computer codes have been developed for the analysis of missile type structures subjected to impulsive loads produced by nuclear effects blowoff. One code, IMPLATE, is applicable to flat plate structures prestressed by inplane mechanical and thermal loads and the other code, IMPSHELL, can be applied to thin cylindrical shell type structures preloaded by internal pressure. The impulsive loads are calculated with the aid of a photoelectric energy deposition code, KNISH, and a blowoff model. A theory for correlating the nuclear effects blowoff impulse with impulse produced by a laboratory simulation 'exploding fail' technique is presented.

78-1624

Dynamic Elastic-Plastic Response of a Containment Vessel to Fluid Pressure Pulses

G. Nikolakopoulou and F. DiMaggio

Rept. No. TR-52, 56 pp (Feb 1978)

AD-A052 148/4GA

Key Words: Shells, Nuclear reactor components, Containment structures, Fluid-induced excitation

The dynamic analysis of the wall of a fluid-filled unstiffened nuclear containment vessel, to the fluid pressure exerted on it when the relief valve discharge piping is cleared, is extended into the plastic range using two versions of an elastic-plastic shell theory.

SPRINGS

78-1625
Saint-Venant's Principle for a Helical Spring

R.C. Batra
Dept. of Engrg. Mechanics, Univ. of Missouri-Rolla, Rolla, MO, J. Appl. Mech., Trans. ASME, 45 (2), pp 297-301 (June 1978) 1 fig, 10 refs

Key Words: Helical springs, Elastic properties, Saint-Venant's Principle

A linear elastic helical spring of arbitrary length and of uniform cross section loaded by a self-equilibrated force system at one end only is considered. We show that the elastic energy, stored in the portion of the spring beyond a certain distance from the loaded end, decreases exponentially with the distance. We thus establish an analog of Toupin's version of the Saint-Venant principle for a helical spring.

78-1626
The Numerical Solution of the Dynamic Response of Helical Springs

S.K. Sinha and G.A. Costello
Dept. of Theoretical and Appl. Mechanics, Univ. of Illinois at Urbana-Champaign, Urbana, IL, Intl. J. Numer. Methods Engr., 12 (6), pp 949-961 (1978) 6 figs, 13 refs

Key Words: Helical springs, Numerical analysis, Finite difference method, Method of characteristics

Consideration is given, in this paper, to the numerical solution of the problem of the dynamic response of helical springs. The behavior is governed by a set of two coupled non-linear wave equations. The problem has been solved by finite differences and the method of non-linear characteristics. The results of these two numerical techniques are compared with the closed form solution of the governing equations in linear form.

STRUCTURAL

78-1627
Seismic Hardening of Unreinforced Masonry Walls Through a Surface Treatment

J.R. Cagley
Martin and Cagley, Rockville, MD, 29 pp (Mar 31, 1978)
PB-278 930/3GA

Key Words: Walls, Masonry, Earthquake resistant structures, Coatings

The primary objective of this project was to determine the feasibility of using a coating or surface treatment to achieve seismic hardening of unreinforced masonry walls. This was accomplished by assembling available information on methods of reinforcing existing masonry which are now in use, by reviewing available test data of unreinforced masonry, by researching available coatings, by determining anticipated required stress levels and by evaluating the results of all of these efforts toward establishing the feasibility of the idea. Since the surface bonding cement appears to have excellent possibilities, an outline for Phase II was developed. The use of surface bonding cement to accomplish seismic hardening of existing unreinforced masonry walls is a potentially economical solution to a problem that at present only has expensive solutions.

78-1628
Structural Response to Simulated Nuclear Overpressure (STRESNO): A Test Program and Future Analytical Techniques. Volume I

R.P. Syring and W.D. Pierson
Boeing, Wichita, KS, Rept. No. D3-9788-5-Vol-1, DNA-4278F-1, AD-E300 093, 202 pp (Mar 1977)
AD-A050 700/4GA

Key Words: Structural members, Nuclear explosion effects, Experimental results, Computer programs

This document reports on the following: Experimental determination of the ability of 17 basic structural elements to withstand simulated nuclear overpressure loads (utilizing Sandia Corporation's THUNDERPIPE Shock Tube) and uniform static pressure loads; Analytical determination of the ability of these structural elements to withstand nuclear overpressure loads and uniform static pressure loads (utilizing the NOVA-2 computer program developed by Kaman AviDyne for the Air Force Weapons Laboratory, Finite element techniques, and classical strength analysis techniques); Identification and evaluation of differences between test results and analysis results; Identification of suggested changes to NOVA-2 to upgrade its capabilities; Analytical determination of the sensitivity of structural response to selected structural properties; and Application to study results to future nuclear hardness assessments.

78-1629
Structural Response to Simulated Nuclear Overpressure (STRESNO): A Test Program Establishing a Data Base for Evaluating Present and Future Analytical Techniques. Volume II. Program Data

R.P. Syring and W.D. Pierson

Boeing Co., Wichita, KS, Rept. No. D3-9788-5-VOL-2, DNA-4278F-2, AD-E300 094, 684 pp (Mar 1977)
AD-A052 029/6GA

Key Words: Structural members, Nuclear explosion effects, Experimental results, Computer programs

This document reports on the following: Experimental determination of the ability of 17 basic structural elements to withstand simulated nuclear overpressure loads (utilizing Sandia Corporation's THUNDERPIPE Shock Tube) and uniform static pressure loads; Analytical determination of the ability of these structural elements to withstand nuclear overpressure loads and uniform static pressure loads (utilizing the NOVA-2 computer program developed by Kaman Avi-Dyne for the Air Force Weapons Laboratory, Finite element techniques and classical strength analysis techniques); Identification and evaluation of differences between test results and analysis results; Identification of suggested changes to NOVA-2 to upgrade its capabilities; Analytical determination of the sensitivity of structural response to selected structural properties; and Application of study results to future nuclear hardness assessments.

SYSTEMS

ABSORBER

(Also see No. 1546)

78-1630

Shock Isolator for Operating a Diode Laser and Closed-Cycle Refrigerator

D.E. Jennings

Goddard Space Flight Center, NASA, Greenbelt, MD, Rept. No. N78-19515/3, NASA-CASE-GSC-12297-1, 14 pp (Feb 1978)
Sponsored by NASA
PAT-APPL-880 838/GA

Key Words: Shock absorbers

A diode laser mounted within a helium refrigerator is mounted using a braided copper ground strap which provides good impact shock isolation from the refrigerator cold-tip while also providing a good thermal link to the cold-tip. The diode mount also contains a rigid stand-off assembly consisting of alternate sections of nylon and copper which serve as cold stations to improve thermal isolation from the vacuum housing mounting structure. Included in the mount is a Pb-In alloy wafer inserted between the cold-tip and the diode to damp temperature fluctuations occurring at the cold-tip.

78-1631

Foam Cylinder Forms Self-Contained Shock Absorber

Des. News, 34 (14), pp 74-75 (July 17, 1978) 3 figs

Key Words: Shock absorber, Foams, Cylinders

A line of heavy-duty adjustable shock absorbers for industrial use includes a group of self-contained units that operate without benefit of an external accumulator. These shock absorbers, have an internal system that includes a thick-walled cylinder of closed-pore elastomer foam. During the deceleration phase of shock-absorber operation, this foam is compressed (from all sides) by the pressurized fluid escaping in front of the shock-absorber piston through the metering orifices. This compression process creates a volume for temporary take-up and storage of the very fluid that produces the compression. During the return stroke, reduction in the fluid pressure resulting from return-spring induced movement of the piston allows the compressed foam to expand to its original shape. This expansion drives the oil back through the orifice into the space behind the returning piston.

78-1632

Reduction of Offshore Platform Dynamic Response by Tuned Mass Damper

R.A. Glacel

Massachusetts Inst. of Tech., Cambridge, MA, 141 pp (May 1977)
AD-A053 324/0GA

Key Words: Tuned dampers, Off-shore structures

An investigation of a tuned mass damper for reduction of offshore oil platform motions is conducted using finite element tower models disturbed by discretized wave spectra. Vibration control principles and their application to offshore oil platforms are discussed. Changes in system response are examined as damper parameters are varied. Response reduction and damper mass motion are found to be coequal design considerations. An assessment is made of a tuned mass damper's effectiveness in reducing the effects of increasing the natural period of offshore platforms, fatigue in steel-jacketed platforms, and soil-degradation under gravity platforms.

NOISE REDUCTION

78-1633

Constructional Application of Noise Attenuating Coverings in Mechanical Engineering

C. Betzhold and H. Gahlau

VDI Z, 120 (11), pp 525-530 (1978) 17 figs, 4 refs
(In German)

Key Words: Noise reduction, Coatings, Structural members

Some fundamental aspects are discussed with regard to meaningful measures for the noise abatement. The authors point out the correct application of attenuating systems and some acoustical deficiencies of frequently used construction-al elements. Furthermore, examples chosen from the power-propelled vehicle engineering and the mechanical engineering show that in the case of a good collaboration between acoustics and design a development is possible of economically representable solutions for the noise attenuation.

ACTIVE ISOLATION

78-1634

Active Sound Absorption in an Air Conditioning Duct

G. Canevet
Laboratoire de Mecanique et d'Acoustique, Centre National de la Recherche Scientifique, 31 Chemin Joseph Aiguier, 13274 Marseille Cedex 2, France,
J. Sound Vib., 58 (3), pp 333-345 (June 8, 1978) 14 figs, 14 refs

Key Words: Active absorption, Acoustic absorption, Ducts

Jessel's theory of active sound absorption has allowed the design and construction of practical systems. In this paper, two recent tripolar absorbers are described and a few experimental results are presented. Absorption experiments were performed successively on pure tones, narrow band noise and broadband noise, propagating in an air conditioning duct. For these three categories of noises, the attenuations achieved were respectively 45 dB, 15 dB and 10 dB.

AIRCRAFT

(Also see Nos. 1539, 1558)

78-1635

Interior Noise Studies for General Aviation Types of Aircraft. Part 1: Field Studies

S.K. Jha and J.J. Catherines
School of Automotive Studies, Cranfield Inst. of Tech., Cranfield, Bedford MK43 0AL, UK,
J. Sound Vib., 58 (3), pp 375-390 (June 8, 1978) 20 figs, 1 table, 5 refs

Key Words: Aircraft noise, Interior noise, Sound transmission, Acoustic absorption

The interior noise level of a general aviation aircraft under various operating conditions is determined and the major sources of the noise and their relative importance are identified. A comparison between the interior noise under stationary conditions on the ground and in flight is shown. The exterior near field and far field noise around the aircraft is measured and its relation to the interior noise field is established. The acoustic attenuation characteristics of a fuselage is also studied.

78-1636

Interior Noise Studies for General Aviation Types of Aircraft. Part II: Laboratory Studies

S.K. Jha and J.J. Catherines
School of Automotive Studies, Cranfield Inst. of Tech., Cranfield, Bedford MK43 0AL, UK,
J. Sound Vib., 58 (3), pp 391-406 (June 8, 1978) 15 figs, 6 refs

Key Words: Aircraft noise, Interior noise, Sound transmission, Acoustic absorption

Laboratory tests were conducted on a light aircraft fuselage to investigate its sound transmission paths and interior noise characteristics. The acoustic attenuation characteristics and the relative effectiveness of different parts of the fuselage for sound attenuation were studied.

78-1637

Rotary-Wing Aircraft Operational Noise Data

B. Homans, L. Little, and P.D. Schomer
Construction Engrg. Research Lab (Army), Champaign, IL,
Rept. No. CERL-TR-N-38, 70 pp (Feb 1978)
AD-A051 999/1GA

Key Words: Aircraft noise, Helicopter noise, Equivalent sound levels

This report presents Sound Exposure Level (SEL) vs distance curves for eight models of Army rotary-wing aircraft (OH-58, AH-1G, UH-1M, UH1-1H, UH-1B, CH-47B, CH-54, and TH-55) performing dynamic operations, and Equivalent Sound Level contours for the same aircraft in static opera-

tions. The dynamic operations consisted of level fly overs, ascents, descents, turns, takeoffs, and landings; static operations included in-ground and out-of-ground effect hovers. Results are grouped according to model and type of operation and are suitable for use in manual or computerized programs for predicting noise impact from rotary-wing aircraft.

78-1638

Atmospheric-Absorption Adjustment Procedure for Aircraft Flyover Noise Measurements

A.H. Marsh

Dytec Engineering, Inc., Huntington Beach, CA, Rept. No. DYTEC-R-7705, FAA-RD-77-167, 90 pp (Dec 1977)

AD-A051 700/3GA

Key Words: Aircraft noise, Noise measurement

An analytical method was developed for adjusting measured aircraft noise levels for differences in atmospheric absorption between test and reference meteorological conditions along the sound propagation path. The method is based on the procedure in the proposed American National Standard ANS S1.26 for calculating pure-tone sound absorption as a function of the frequency of the sound and the temperature, humidity, and pressure of the air. Measured aircraft noise levels are assumed to be 1/3-octave-band sound pressure levels. A computer program was written in FORTRAN IV to carry out the calculations. The operation of the computer program, the required input data, and all symbols and terms used in the program are described. A program listing of source statements is provided. Recommendations are given for applying the method to routine processing of aircraft noise measurements.

78-1639

Measurement of Non-Diagonal Generalized Damping Ratios During Ground Vibration Tests

G. Coupry

European Space Agency, Paris, France, In: Its La Rech, Aerospatiale, Bi-monthly Bull. No. 1977-4 (ESA-TT-428), pp 53-65 (Nov 1977) (Engl. transl. from La Rech. Aerospatiale, Bull. Bimestriel, Paris, No. 1977-4, pp 239-244 (July/Aug 1977)

N78-23037

Key Words: Aircraft, Damping values, Vibration tests

Problems in measuring the nondiagonal damping ratios of a structure during ground vibration tests are discussed: in particular, a theoretical difficulty arising in the analysis of nondiagonal damping ratios due to dissipative coupling between the modes of the structure. Errors in the classical determination of vibratory effects through isolation of the excitations of the various modes were assessed; the use of generalized masses, deformations and damping ratios, instead of adapted values based on the concept of equiphase response, is suggested to eliminate the faulty analysis. A simple problem involving the nondiagonal damping ratios of a small twin-engined plane is also given.

78-1640

Calculation of Unsteady Airloads on Oscillating Three-Dimensional Wings and Bodies

W. Geissler

Inst. f. Aeroelastik, Deutsche Forschungs- und Versuchsanstalt f. Luft- und Raumfahrt, Goettingen, West Germany, In: AGARD Unsteady Aerodyn., 13 pp (Feb 1978)

N78-22038

Key Words: Aircraft wings, Aircraft, Oscillation, Numerical analysis

A numerical method developed to calculate the steady and unsteady pressure distributions on harmonically oscillating three dimensional wings and bodies in subsonic flow is described. The method is based on a complex velocity potential represented by appropriate singularity distributions on the real oscillating surfaces. The exact geometric boundary condition on the arbitrary body surface is considered. Oscillating three dimensional thin wings, oscillating bodies at incidence, and oscillating three dimensional wings with finite thickness and incidence were investigated intensively. Numerical results for a variety of problems were compared to other analytical methods as well as experimental data. Agreement was found to be satisfactory.

78-1641

Force Measurements on Finite Wings in Oscillatory Vertical Gusts

M.H. Patel

Dept. of Mech. Engrg., Univ. College, London, UK, In: AGARD Unsteady Aerodyn., 16 pp (Feb 1978)

N78-22037

Key Words: Aircraft wings, Wind-induced excitation, Experimental data

Aerodynamic lift and pitching moment measurements on two finite wings in harmonic vertical oscillatory gusts of varying frequency parameter and gust amplitude are described. The variation of aerodynamic force per unit gust amplitude with frequency parameter is shown to be independent of freestream velocity, wing incidence, and gust amplitude, but is strongly influenced by wing sweep. The tests on both wings are extended to the determination of aerodynamic force response to periodic vertical gusts which incorporate a combination of two harmonic frequency components. The validity of the superposition concept for unsteady attached flow over finite wings is demonstrated by comparing the components of force response at each of the two forcing frequencies to the corresponding response at the single harmonic frequency. Further measurements of lift, pitching moment, and rolling moment are presented for both wings at various attitudes of skew (in yaw) to a harmonic oscillatory gust front. The effects of the resultant asymmetric lift distribution on the two wings halves are identified in the results with particular reference to the amplitudes and phases of oscillating rolling moments that are generated.

BRIDGES

78-1642

Dynamic Response of Skew Bridge Decks

R.S. Srinivasan and K. Munaswamy
Dept. of Appl. Mechanics, Indian Inst. of Tech., Madras, India, Intl. J. Earthquake Engr. Struc. Dynam., 6 (2), pp 139-156 (Mar/Apr 1978) 9 figs, 4 tables, 13 refs

Key Words: Bridges, Moving loads, Skew plates, Orthotropic plates, Finite strip method

In this paper the dynamic response of a skew bridge deck has been investigated, treating it as an orthotropic plate and using the finite strip method. Employing the normal mode method, the response of the deck due to a moving force has been calculated. Williams' method has been used to accelerate the convergence of the solution. Numerical work has been done for different skew angles and speed ranges. In this study, the history curves and the maximum amplification spectra for deflection and bending moment are presented.

BUILDING

(Also see Nos. 1532, 1533, 1538, 1547)

78-1643

Natural Vibrations of Shear Wall Buildings on Flexible Supports

A. Coull and P.R. Mukherjee
Dept. of Civil Engrg., Univ. of Glasgow, Glasgow, UK, Intl. J. Earthquake Engr. Struc. Dynam., 6 (3), pp 295-315 (May/June 1978) 5 figs, 4 tables, 11 refs

Key Words: Buildings, Walls, Flexible foundations, Natural frequencies, Mode shapes, Ritz-Galerkin technique

A shear wall building is considered as an assembly of plane and curvilinear shear walls tied together by floor slabs to act as a composite unit. Based on this conception and the continuous medium approach, the governing dynamic equations and boundary conditions are derived from energy principles, using Vlasov's theory of thin-walled beams. All primary and secondary inertia forces, as well as the influence of elastic foundation flexibility, have been taken into consideration. A numerical solution of the dynamic equations is achieved by employing the Ritz-Galerkin technique, yielding both natural frequencies and mode shapes. The technique is applicable to buildings containing coupled and non-coupled, open section shear walls oriented in plan in any arbitrary manner. The use of the method is illustrated by the example of a complex building with unsymmetric plan, and the analytical natural frequencies of two shear wall building models are compared with those obtained experimentally by other investigators.

78-1644

Approximate Frequency Analysis of Shear Wall Frame Structures

Y.K. Cheung and C. Kasemset
Dept. of Civil Engrg., Univ. of Adelaide, Adelaide, Australia, Intl. J. Earthquake Engr. Struc. Dynam., 6 (2), pp 221-229 (Mar/Apr 1978) 11 figs, 14 refs

Key Words: Multistory buildings, Walls, Framed structures, Seismic response, Finite strip method

The finite strip method is used to determine the natural frequencies of shear wall frame buildings. The structure can be modeled in two different ways. In the first approach both the shear walls and the frames are idealized simply as an assemblage of finite strips of varying thicknesses with given or computed properties, while in the second approach the shear walls are still idealized as a series of finite strips, but the frames are regarded as a number of long columns which are interconnected with each other or with finite strips through the horizontal beams. Numerical results obtained from both models indicate good agreement with finite element solutions. The proposed models can be applied to a wide range of shear wall frame assemblies and are therefore more versatile than most existing models.

78-1645

Preliminary Experimental Study of Seismic Uplift of a Steel Frame

R.W. Clough and A.A. Huckelbridge, Jr.
Earthquake Engrg. Res. Center, California Univ., Richmond, CA, Rept. No. UCB/EERC-77/22, 171 pp

(Aug 1977)
PB-278 769/5GA

Key Words: *Buildings, Steel, Earthquake response*

This study represents the preliminary portion of a research program into the effects of allowing column uplift in steel building frames responding to severe seismic loading. Included in this report are experimental and analytical results for a 3-story steel frame both with and without column uplift allowed. Uplift response results are presented for tests using 2 sets of impact elements with stiffnesses differing by approximately an order of magnitude. Allowing column uplift is shown for this frame to significantly reduce both the seismic loading and ductility demand, when compared to the fixed base response for a similar input motion. An analytical technique employing bilinear elastic foundation support elements, with no tensile capacity or stiffness in the upward direction, is shown to accurately predict the uplift response of this frame, even in the presence of large rigid body rotations. An analytical technique using concentrated bilinear plastic hinges is shown to accurately predict the nonlinear fixed base response, for moderately nonlinear response.

78-1646
The Vibrational Characteristics of a Twelve-Storey Steel Frame Building
D.A. Foutch
Univ. of Illinois at Urbana-Champaign, Urbana, IL, Intl. J. Earthquake Engr. Struc. Dynam., 6 (3), pp 265-294 (May/June 1978) 23 figs, 6 tables, 15 refs

Key Words: Buildings, Framed structures, Steel, Vibration tests, Torsional response, Finite element technique

A twelve-story steel frame structure, was subjected to a series of forced vibration tests. The natural frequencies, three-dimensional mode shapes and damping coefficients of nine modes of vibration were determined. Other features of this investigation included the study of non-linearities associated with increasing levels of response, detailed measurements of the deformation of the first floor and the ground surrounding the structure, and measurements of strain in one of the columns of the structure during forced excitation. The dynamic characteristics of the building determined by these tests are compared to those predicted by a finite element model of the structure. The properties of primarily translational modes are predicted reasonably well, but adequate prediction of torsional motions is not obtained. The comparison between measured and predicted strains suggests that estimates of stress determined from finite element analyses of buildings might be within 25 percent of those experienced by the structure for a known excitation.

78-1647
Earthquake Simulation Tests of a Nine Story Steel Frame with Columns Allowed to Uplift
A.A. Huckelbridge, Jr.
Earthquake Engrg. Res. Center, California Univ., Berkeley, CA, Rept. No. UCB/EERC-77/23, 193 pp (Aug 1977)
PB-277 944/5GA

Key Words: Multistory buildings, Framed structures, Steel, Seismic response

This thesis presents experimental and analytical response data for a model nine-story building frame under seismic excitation, both with and without supplementary anchorage of the columns provided. The experimental work was carried out on the shaking table of the U.C. Berkeley Earthquake Simulator Laboratory. Appreciable amounts of column uplift were observed in the tests for which column uplift was permitted, with significant reductions in the lateral loading, when compared to the fixed base response. An analytical technique employing bilinear foundation support elements with zero tensile capacity and stiffness in the upward direction is shown to predict the uplifting response with excellent accuracy. Analytical predictions of the nonlinear fixed base response, employing concentrated bilinear plastic hinges are also shown to be very accurate for the levels of nonlinearity encountered.

78-1648
Non-Linear Analysis of a Deeply Embedded Power Plant Building Subjected to Earthquake Load
S. Mukherjee and W. Korner
Brown Boveri Rev., 65 (3), pp 189-192 (Mar 1978) 4 figs, 6 refs

Key Words: Electric power plants, Earthquake response, Mathematical models, Nonlinear theories

The dynamic response of a power plant building on deeply embedded foundations to excitation by earthquake is investigated in this analysis. The building and soil structures can be simulated by a mathematical model using two-dimensional finite elements. Non-linear soil material and linear building properties were assumed for dynamic analysis. Comparison of the foundation response spectra determined by non-linear analysis shows decreasing accelerations in the lower frequency range, which has a favorable effect on power plant building and component dimensions. Plastic areas which form under the foundation slab over a period of time are also investigated.

FOUNDATIONS AND EARTH

78-1649
Foundation Response to Soil Transmitted Loads
S.N. Varadhi, S.K. Saxena, and E. Vey
Dept. of Civil Engrg., Illinois Inst. of Tech., Chicago, IL, Rept. No. GEOTECHNICAL SER-77-201, 222 pp (Dec 1977)
PB-279 055/8GA

Key Words: Foundations, Buildings, Seismic excitation

This research deals with effects on foundation response produced by stress waves propagating from underlying soils. A circular footing was located at the surface and at different depth of burial and a transient load was applied to the footings through the underlying soils. Stress-time and strain-time histories were recorded through embedded gages. These records were correlated with acceleration-time records of the input load and foundation response to provide a comprehensive picture of stresses and strains in a soil mass subjected to earthquake type loading. The investigation also includes some static and dynamic experiments, conducted using a thin layer of compressible material buried at depths of one radius below the footing.

HELICOPTERS

(Also see Nos. 1529, 1551, 1606)

78-1650
Comparison of Measured and Calculated Helicopter Rotor Impulsive Noise
W. Johnson and A. Lee
Ames Res. Center, NASA, Moffett Field, CA, Rept. No. NASA-TM-78473; A-7355, 29 pp (Mar 1978)
N78-20917

Key Words: Helicopter noise, Wind tunnel tests, Rotary wings, Geometrical effects

The thickness noise theory is discussed. Two full-scale rotors were tested in a wind tunnel with several tips involving changes in chord, thickness, and sweep. Impulsive noise data reduction procedures used are described. The calculated and measured impulsive noise peak pressures as a function of advancing tip Mach number are compared, showing good correlation for all rotors considered.

78-1651
Acoustical Effects of Blade Tip Shape Changes on a Full Scale Helicopter Rotor in a Wind Tunnel
A. Lee
Beam Engineering, Inc., Sunnyvale, CA, Rept. No. NASA-CR-152082, 59 pp (Apr 1978)
N78-20918

Key Words: Helicopter noise, Wind tunnel test, Rotary wings, Geometrical effects

Four tip shapes were tested. They were rectangular, swept, tapered, and swept-tapered. The measured data covered a wide range of operating conditions. The range of advancing tip Mach numbers were between 0.72 to 0.96, and the advance ratios were from 0.2 to 0.375. At low and moderate advancing tip Mach number, the data in the dbA scale appear to indicate the swept tip is the quietest, swept tapered the second, tapered third and rectangular the most noisy. Above an advancing tip Mach number of about 0.89, a distinct acoustical pulse can be observed, which dominates the acoustical waveform. The pulse shape is symmetric at moderate tip Mach number, changing to a sawtooth shape at high advancing tip Mach numbers.

HUMAN

(Also see Nos. 1558, 1560, 1562)

78-1652
Individual Variability and Its Effect on Subjective and Biodynamic Response to Whole-Body Vibration
M.J. Griffin and E.M. Whitham
Inst. of Sound and Vib. Research, Univ. of Southampton, Southampton S09 5NH, UK, J. Sound Vib., 58 (2), pp 239-250 (May 22, 1978) 4 figs, 5 tables, 10 refs

Key Words: Human response, Vibration excitation

The experiment described in this paper was designed to evaluate the differences in discomfort and body transmissibility between and within different population groups and to attempt to discover physical causes of the differences. The responses of one hundred-and-twelve seated subjects to vertical (z-axis) sinusoidal vibration at 4 Hz and 16 Hz were investigated. The subjects were in three groups (56 men, 28 women and 28 children) and were of varied demography. In the first part of the experiment they were required to make seven judgments indicating which of seven levels (in the range 0.41 to 2.46 m/s^2 rms) of 16 Hz vibration caused more discomfort than a fixed level (1.0 m/s^2 rms) of 4 Hz vibration. In the second part of the experiment the transmission of vertical vibration from seat to head was measured at the same two frequencies.

78-1653
The Effect of Low Frequency Noise on People -- A Review

N. Broner
Dept. of Physics, Chelsea College, Univ. of London, London SW6 5PR, UK, J. Sound Vib., 58 (4), pp 483-500 (June 22, 1978) 7 figs, 2 tables, 121 refs

Key Words: Noise, Human response

During the last few years, the existence of high levels of man-made low frequency noise (0 - 100 Hz), and in particular infrasonic noise, has been reported in many environments. An effort has been made over the last decade to discover whether such high levels of low frequency noise are significant. A review of the effects of low frequency noise indicates that the effects are similar to those of higher frequency noise, that noise in the 20 - 100 Hz range is much more significant than infrasound at similar sound pressure levels and that the possible danger due to infrasound has been much over-rated.

78-1654
Calibration Procedures of Test Dummies for Side Impact Testing
J.W. Melvin and J.B. Benson
Highway Safety Res. Inst., Michigan Univ., Ann Arbor, MI, Rept. No. UM-HSRI-77-13, DOT-HS-803 253, 210 pp (Mar 14, 1977)
PB-278 299/3GA

Key Words: Collision research (automotive), Testing techniques, Anthropomorphic dummies

The objectives of the study were to develop and establish recommended tests, testing procedures and calibration criteria by which test dummies can be characterized and qualified for side impact compliance testing. The test procedures developed in this program were based on a review of available biomechanics literature, car crash tests, accident investigation data and impact sled tests. The tests which were developed are simple to perform and can be done using the apparatus for existing Part 572 frontal tests.

78-1655
Restraint System Evaluation – A Comparison Between Barrier Crash Tests, Sled Tests and Computer Simulation
H. Mellander and M. Koch
Car Industry Div., AB Volvo, SAE Paper No. 780-605, 12 pp, 15 figs, 3 refs

Key Words: Collision research (automotive), Experimental data, Anthropomorphic dummies, Mathematical models

The injury criteria measured in belted dummies in frontal barrier crash tests are compared to results from two alternative evaluation methods: Sled tests and mathematical simulation. The recorded values from the barrier crash tests and sled tests are compared by two different statistical inference tests in order to establish a possible significant difference between the methods.

78-1656
Multi-Rigid-Body System Dynamics with Applications to Human-Body Models and Finite-Segment Cable Models
R.L. Huston and C.E. Passerello
Dept. of Engrg. Science, Cincinnati Univ., Cincinnati, OH, Rept. No. UC-ES-080177-4-ONR, 66 pp (Aug 1977)
AD-A052 868/7GA

Key Words: Collision research (automotive), Human response, Computerized simulation

A computer-oriented method for obtaining dynamical equations of motion for large mechanical systems or chain systems is presented. A chain system is defined as an arbitrarily assembled set of rigid bodies such that adjoining bodies have at least one common point and such that closed loops are not formed. The equations of motion are developed through the use of Lagrange's form of d'Alembert's principle. The method is illustrated and applied with human-body models and finite-segment cable models. The human-body models are configured to simulate a crash-victim.

ISOLATION

78-1657
Dynamic Analysis of Shipping Container Suspension System for the ASROC Launched Version of the HARPOON Missile RGM-84-A-1
G. Johnson
Naval Weapons Handling Center, Colts Neck, NJ, Rept. No. NWHC-7732, 98 pp (May 16, 1977)
AD-A051 422/4GA

Key Words: Isolators, Shipping containers, Storage tanks, Computer programs, Transportation effects

An analysis was conducted by Naval Weapons Handling Center, WPNSTA Earle to determine isolation system parameters for a shipping and storage container to be used with the ASROC launched version of the HARPOON missile. A computer program package specifically written for container designers was used and is the main computational tool in the analysis. Two possible solutions to the isolation systems are presented. The primary difference between the solutions is that unlike Solution 1, Solution 2 uses offset isolators, thereby resulting in better placed longitudinal and vertical frequencies and lower sway space requirements. This report presents the details of the analysis and provides information concerning the predicted shock and vibration forces on the weapon caused by the hazards of transportation and handling.

78-1658

Ride Comfort and Road Holding of a 2-DOF Vehicle Travelling on a Randomly Profiled Road

T. Dahlberg

Div. of Solid Mechanics, Chalmers Univ. of Tech., Fack, S-402 20 Gothenburg, Sweden, J. Sound Vib., 58 (2), pp 179-187 (May 22, 1978) 4 figs, 13 refs

Key Words: Suspension systems (vehicles), Ride dynamics

The suspension of a two-degree-of-freedom (2-DOF) vehicle traveling on a randomly corrugated road is optimized with respect to both road holding and ride comfort. Optimal comfort is defined as a minimum mean value of the largest maxima of a stationary Gaussian random process. This process is the vertical vehicle seat acceleration weighted with respect to human sensitivity (ISO 2631). Optimal road holding is defined as a minimum probability that the road-wheel contact force will be smaller than a given level. This contact force is conceived as another stationary Gaussian random process. The two criteria are synthesized and the suspension system is optimized with respect to the joint criterion obtained. One restriction accounted for is the limited working space of the vehicle suspension.

MECHANICAL

78-1659

Analog and Digital Computer Simulation of Coulomb Friction

R. Heller, J.M. Tuten, P.S. Kadala, and E.H. Law

Dept. of Mech. Engrg., Clemson Univ., SC, Rept. No. FRA/ORD-78/07, 61 pp (Dec 1977)

PB-279 465/9GA

Key Words: Suspension systems (vehicles), Railway cars, Freight cars, Coulomb friction, Computerized simulation, Computer programs

Coulomb friction, such as found in the suspension system of railway freight cars, can strongly influence dynamic behavior. The Coulomb friction nonlinearity must be accurately implemented in computer simulations of multi-degree-of-freedom dynamic models. This report proposes three computer models for friction and analyzes their performance in analog and digital computer simulations. Simulation techniques used are described in detail. Performance of each friction model is compared to analytical results. The accuracy, advantages, and disadvantages of each model are discussed. The report concludes with recommendations on the use of the proposed friction models.

78-1660

Analysis and Synthesis of a High-Speed Pneumatic Machine Drive

I.I. Artobolevskii and E.V. Hertz

Academician Inst. for the Study of Machines, Academy of Sciences of the USSR, Moscow Center, Ulitsa Griboedova 4, K. 60, USSR, Mech. Mach. Theory, 13 (3), pp 293-300 (1978) 5 figs, 4 refs

Key Words: Pneumatic machine drives, Dynamic synthesis, Computer aided techniques

The paper deals with the problem of increasing the velocity of actuating elements in a pneumatic machine drive. A rational structure of the drive is chosen by a comparative analysis of the dynamic characteristics of different drives. A dynamic analysis by computer of the most promising drive with different parameters is given. As a result the most important design parameters are established. The dynamic synthesis of this drive is made on the basis of reference data generated by the computer using a limited variation of essential parameters. The maximal piston velocity received at limited size and weight of the drive was taken as an optimal criterion. Accordingly, for this method, design parameters of the drive were chosen for which velocity is much higher than for common drives.

78-1661

The Nonsteady Behaviour of Linear Oscillators with Two and More Degrees of Freedom

G. Dittrich and J. Sommer

Institut f. Getriebstechnik u. Maschinendynamic d. RWTH Aachen, Aachen, Germany, VDI Z., 120 (9), pp 419-431 (1978) 24 figs, 4 refs

(In German)

Key Words: Structural elements, Machinery components, Numerical methods

A numerical method for the prediction of structural element loads in a machine during operation is presented. It enables the investigation of the behavior of linear oscillation systems with several degrees of freedom particularly the resonance penetration of systems with two degrees of freedom.

OFF-ROAD VEHICLES

78-1662

The Dynamics of Vehicles on Roads and on Tracks

A. Slibar and H. Springer, Eds.

2nd Intl. Union of Theoretical and Appl. Mech. Symp. (Sept 19-23, 1977) Tech. Univ. Vienna, Austria; Svets and Zeitlinger B.V., Amsterdam, 1978

Key Words: Road vehicles, Computer programs, Interaction: vehicle-guideway, Tires, Handling, High speed transportation systems, Tracked vehicles, Vehicles

The proceedings describes a set of papers given at the 5th Vehicle Systems Dynamics Symposium. Summaries of the papers were abstracted in the Shock and Vibration Digest, Volume 10, No. 1.

PUMPS, TURBINES, FANS, COMPRESSORS

(Also see No. 1591)

78-1663

Control of Tip-Vortex Noise of Axial Flow Fans by Rotating Shrouds

R.E. Longhouse

Fluid Dynamics Res. Dept., General Motors Res. Labs., Warren, MI 48090, J. Sound Vib., 58 (2), pp 201-214 (May 22, 1978) 15 figs, 3 refs

Key Words: Fans, Noise reduction, Shrouds

Noise and performance tests were conducted on a low tip speed, half-stage, axial flow fan such as is used in automotive applications. The purpose of the tests was to determine the characteristics, relative importance, and the methods of control of the tip clearance noise of the fan. The noise measurements were made in both free field and reverberant field environments and the fan backpressure and speed were varied during the tests. An acenaphthene coating on the blades was used to determine the regions of laminar and turbulent flow and smoke was used to visualize the blade-tip flow patterns.

78-1664

Inlet Flow Distortions in Axial Flow Compressors

J. Colpin

Von Karman Inst. for Fluid Dynamics, Chaussee de Waterloo, 72, B-1640 Rhode Saint Genese, Belgium, Israel J. Tech., 15 (4/5), pp 153-163 (1977) 12 figs, 16 refs

Key Words: Compressors, Rotors, Fluid-induced excitation

This paper treats the inlet circumferential flow distortion problems following two approaches, i.e., a global and a detailed analysis. The first of these approaches develops the parallel compressor model by including an unsteady blade transfer function, which depends essentially on the blade reduced frequency. Thus, the small distortions are well taken into account for the highly unsteady behavior they induce at the rotor. The predictions reached agree fairly well with tests done on a high-speed single-stage compressor distorted with various upstream grids. A simple two-dimensional incompressible model is presented to simulate the rotor dynamic transfer.

78-1665

Prevention of Torsional Vibration of the Shaft System of Motor-Driven Multiblade Fans (1st Report, Natural Vibration and Frequency Response of the Shaft System)

Y. Segawa and F. Fujisawa

Hitachi Res. Lab., Hitachi Ltd., Hitachi, Japan, Bull. JSME, 21 (155), pp 806-815 (May 1978) 7 figs, 4 tables, 10 refs

Key Words: Rotors, Fans, Shafts, Torsional vibration, Vibration control

The authors analyzed torsional natural vibration of the fan shaft system of a multiblade fan, motor-driven by thyristor speed controller, and described the key points in design for vibration reduction. In analysis, it was assumed that the blades were beams, and the vibration system was a linear and branch shaft system, and transfer matrix method was used. For frequency response analysis, especially, material damping of each part of the system and damping due to solid friction of the bearings were considered. Analytical results were confirmed experimentally.

78-1666

Reduction of Fan Noise in an Anechoic Chamber by Reducing Chamber Wall Induced Inlet Flow Disturbances

J.H. Dittmar, M.J. Mackinnon, and R.P. Woodward

Lewis Res. Center, NASA, Cleveland, OH, Rept. No. NASA-TM-78854; E-9580, 20 pp (1978)
N78-22860

Key Words: Fans, Turbofan engines, Noise reduction, Experimental data

The difference between the flight and ground static noise of turbofan engines presents a significant problem in engine noise testing. The additional noise for static testing has been attributed to inlet flow disturbances or turbulence interacting with the fan rotor. In an attempt to determine a possible source of inflow disturbances entering fans tested in the Lewis Research Center anechoic chamber, the inflow field was studied using potential flow analysis. These potential flow calculations indicated that there was substantial flow over the wall directly behind the fan inlet that could produce significant inflow disturbances. Fan noise tests were run with various extensions added to the fan inlet to move the inlet away from this backwall and thereby reduce the inlet flow disturbances. Significant noise reductions were observed with increased inlet length.

RAIL

(See Nos. 1562, 1659)

REACTORS

78-1667

Coupled Problems in Transient Fluid and Structural Dynamics in Nuclear Engineering. Part 2: A Discrete Model for Squeeze Flow Between Two Adjacent LMFBR Subassemblies

H. Zehlein
Institut f. Reaktorentwicklung, Gesellschaft f. Kernforschung mbH, Postfach 3640, 7500 Karlsruhe, West Germany, Appl. Math. Modeling, 2 (2), pp 90-98 (June 1978) 10 figs, 28 refs

Key Words: Interaction: structure-fluid, Nuclear reactor components

The paper deals with a detailed investigation of the interaction between sub-assemblies and coolant dynamics within an LMFBR core under transient pressure loading. The one-dimensional discrete model approximates the axial squeeze flow by a combined Lagrangian particle Euler cell approach. The coupling between the fluid and the structure is achieved by a step by step scheme. An energy balance criterion is used to improve its computational efficiency. An extension for two-dimensional squeeze flow, where axial and transverse flow around the subassembly may occur, completes the mathematical model.

78-1668

Coupled Problems in Transient Fluid and Structural Dynamics in Nuclear Engineering. Part 1: Safety Problems Solved by Flow Singularity Methods

R. Krieg
Institut f. Reaktorentwicklung, Gesellschaft f. Kernforschung mbH, Postfach 3640, 7500 Karlsruhe, West Germany, Appl. Math. Modeling, 2 (2), pp 81-89 (June 1978) 10 figs, 28 refs

Key Words: Interaction: structure-fluid, Nuclear reactors

Some important problems in coupled fluid-structural dynamics which occur in safety investigations of liquid metal fast breeder reactors (LMFBR), light water reactors and nuclear reprocessing plants are discussed and a classification of solution methods is introduced. A distinction is made between the step by step solution procedure, where available computer codes in fluid and structural dynamics are coupled, and advanced simultaneous solution methods, where the coupling is carried out at the level of the fundamental equations. Results presented include the transient deformation of a two-row pin bundle surrounded by an infinite fluid field, vapor explosions in a fluid container and containment distortions due to bubble collapse in the pressure suppression system of a boiling water reactor. A recently developed simultaneous solution method is presented in detail. Here the fluid dynamics (inviscid, incompressible fluid) is described by a singularity method which reduces the three-dimensional fluid dynamics problem to a two-dimensional formulation. In this way the three-dimensional fluid dynamics as well as the structural (shell) dynamics can be described essentially by common unknowns at the fluid-structural interface. The resulting equations for the coupled fluid-structural dynamics are analogous to the equations of motion of the structural dynamics alone.

78-1669

Computer Models for Subassembly Simulation

T.B. Belytschko and J.M. Kennedy
Dept. of Civil Engrg., Northwestern Univ., Evanston, IL 60201, Nucl. Engr. Des., 49 (1/2), pp 17-38 (July 1978) 26 figs, 22 refs
Sponsored by the Dept. of Energy

Key Words: Nuclear reactor components, Nuclear fuel elements, Interface: solid-fluid, Interaction: structure-fluid, Finite element technique, Mathematical models

Two-dimensional finite element models for the treatment of the nonlinear, transient response of fluids and structures are described. The fluid description is quasi-Eulerian, so that the mesh can move independently of the material and it includes a new finite element upwinding scheme. The structural description is based on a corotational formulation in which the coordinate system is embedded in the elements, and which is applicable to arbitrarily large rotations. The interface between the fluid and structure permits relative sliding, but because of the quasi-Eulerian fluid description the nodes of the fluid and structure can be allowed to remain contiguous. Modeling procedures for treating the various aspects of subassemblies, such as the narrow fluid channels, the fuel bundles which are immersed in the coolant, and the axial flow, are developed. Calculations are made for a symmetric seven-subassembly cluster and compared to experimental results. In addition, the application to a 19-subassembly cluster is described.

78-1670

A Numerical Method for Predicting Seismic-Induced Impact Between Subassemblies in LMFBR Cores

H.L. Schreyer
Reactor Analysis and Safety Div., Argonne National Lab., Argonne, IL, Nucl. Engr. Des., 49 (1/2), pp 69-78 (July 1978) 10 figs, 1 table, 3 refs
Sponsored by the Dept. of Energy

Key Words: Nuclear reactor components, Nuclear fuel elements, Seismic response, Numerical methods

Structural problems that incorporate impact usually require small time steps for numerical integration and, consequently, solutions are very expensive. Since impact is one of the basic phenomena involved in any study of fast breeder reactor cores subjected to seismic disturbances, it is imperative that simplified models be introduced to make safety studies economically feasible. An approach is proposed in this paper whereby just the magnitude of each impulse and not the history of the impact force is determined for each impact. The consequence of the procedure is that the maximum time step is governed by system parameters and not by a detailed characteristic of the contact region such as an equivalent contact spring. The concepts are developed with the use of a single-degree-of-freedom model and the approach is applied to a three-assembly model of a reactor core. To obtain a solution, it is shown that the proposed direct approach may result in computer time that is less by an order of magnitude than the time required by the more conventional contact spring and gap element method.

78-1671

Comparison of Finite Element Calculations with Experiments for the Dynamic Response of LMFBR Core Subassembly Ducts

J.E. Ash
Reactor Analysis and Safety Div., Argonne National Lab., Argonne, IL, Nucl. Engr. Des., 49 (1/2), pp 79-92 (July 1978) 13 figs, 9 refs
Sponsored by the Dept. of Energy

Key Words: Nuclear reactor components, Nuclear fuel elements, Dynamic response, Finite element techniques, Computer programs

The capability of a finite-element computer code STRAW to predict the structural response of LMFBR core subassembly hexagonal wrappers to postulated accidental local energy releases has been verified by comparisons with test data from out-of-pile experiments. The code was applied to the analysis of the dynamic response of hexcans subjected to internal pressure pulse loadings, and the computational results were correlated with data from a series of tests on individual hexcan sections. The pressure was generated by a PETN burning mixture. Two specified pressure pulse shapes were generated to simulate hypothetical conditions created by a fuel-coolant interaction resulting from a fuel pin failure. The hexcan dynamic deflections were measured with light-emitting diode (LED) gauges, and the midflat circumferential and axial strains were measured with foil strain gauges. The sensitivity of the response to variations in both the pressure loading and the material properties of the stainless steel were examined. The ductility of the steel was varied by coldworking and annealing. Very low ductility test hexcan specimens were fabricated by coldworking introduced in the drawing process by means of a specially designed set of dies. High ductility specimens were produced by a solution annealing process.

78-1672

Analysis of Nonlinear Fluid-Structure Interaction in LMFBR Containment

C.Y. Wang, Y.W. Chang, and S.H. Fistedis
Reactor Analysis and Safety Div. Argonne National Lab., Argonne, IL, Nucl. Engr. Des., 49 (1/2), pp 93-105 (July 1978) 15 figs, 1 table, 7 refs
Sponsored by the Dept. of Energy

Key Words: Nuclear reactor components, Containment, Interaction: structure-fluid

A generalized Eulerian method has been incorporated into ICECO for analyzing the nonlinear fluid-structure interaction in the primary containment of an LMFBR, consisting of complicated structural components such as the radial shield, core barrel, core-support structure, and the primary vessel. The method employs a Poisson equation to determine the hydrodynamic pressure in the fluid region, while using a relaxation equation to compute the pressure adjacent to the structure. A generalized coupling scheme is developed for treating the sliding condition at the fluid-structure interface, modeling the perforated structure, and analyzing the

fluid motion at the geometrical discontinuities. Detailed formulations are given. Sample problems concerning wave propagation in a typical reactor containment are presented.

78-1673

Dynamic Structural Response of LMFBR Head Closures to Hypothetical Core Disruptive Accidents

R.F. Kulak

Reactor Analysis and Safety Div., Argonne National Lab., Argonne, IL, Nucl. Engr. Des., 49 (1/2), pp 119-129 (July 1978) 15 figs, 3 tables, 3 refs

Sponsored by the Dept. of Energy

Key Words: Nuclear reactor components, Closures, Dynamic structural analysis

Presented here is an investigation of the dynamic structural response of the primary vessel's head closure to a hypothetical core disruptive accident (HCDA). Two head-closure designs were considered: the first represents a loop-type design and the second represents a pool-type design. Using representative configurations of liquid metal fast breeder reactors (LMFBR), independent models were used to derive loading pressure histories and to study the structural response of the head closures. Results for loading pressures, displacement histories, deformed profiles, stress magnitudes and plastically deformed regions are presented.

RECIPROCATING MACHINE

78-1674

Aircraft Engine Design and Development Through Lessons Learned

B.L. Koff

Aircraft Engine Group, General Electric, 1 Jimson Rd., Mail Drop J44, Cincinnati, OH 45215, Israel J. Tech., 15 (4/5), pp 139-152 (1977) 25 figs, 1 table

Key Words: Aircraft engines, Design techniques

A procedure for designing aircraft engines is described which includes a complete engine system vibration analysis using a finite element technique. Experimental analytical methods, e.g., photoelasticity, are used to determine stresses in parts that are difficult to model. In addition, the article discusses materials behavior, engine cyclic endurance testing technique, engine unbalance testing, as well as instrumentation.

78-1675

Feasible Noise Limits for Construction and Maintenance Equipment and Study of Noise Reduction Methods

M.M. Hatano and E.C. Shirley

Transportation Lab., California State Dept. of Transportation, Sacramento, CA, Rept. No. 657083, FHWA/CA-77-18, 154 pp (July 1977)

PB-278 602/8GA

Key Words: Diesel engines, Engine noise, Noise reduction, Construction equipment, Truck engines

This study concerns modifications and evaluation of noise attenuating devices and methods for quieting diesel powered vehicles and construction equipment. The findings were used to develop guidelines for operation and correction of noisy vehicles and equipment and specifications for construction contracts. The major effort was directed towards modification of an existing 1964 diesel powered dump truck to build a 'Quieted Truck'. Changes to the exhaust system, cooling system and building a tunnel around the engine and drive train were successful in significantly reducing noise. The amount of reduction varied depending on factors such as speed and mode of operation. As one example, an estimated reduction from 82 to 73 dBA was measured at 50 feet during an acceleration test at 50 mph. A literature survey and synthesis on diesel powered trucks and construction equipment are a part of this report.

78-1676

A Method for Calculating Strut and Splitter Plate Noise in Exit Ducts: Theory and Verification

M.R. Fink

United Technologies Res. Center, East Hartford, CT, Rept. No. NASA-CR-2955; R77-911739-18, 81 pp (Mar 1978)

N78-20921

Key Words: Engine noise, Noise propagation, Ducts

Portions of a four-year analytical and experimental investigation relative to noise radiation from engine internal components in turbulent flow are summarized. Spectra measured for such airfoils over a range of chord, thickness ratio, flow velocity, and turbulence level were compared with predictions made by an available rigorous thin-airfoil analytical method. This analysis included the effects of flow compressibility and source noncompactness. Generally good agreement was obtained. This noise calculation method for isolated airfoils in turbulent flow was combined with a method for calculating transmission of sound through a subsonic exit duct and with an empirical far-field directivity shape. These three elements were checked separately and were individually shown to give close agreement with data. This combination provides a method for predicting engine internally generated aft-radiated noise from radial struts and stators, and annular splitter rings. Calculated sound power spectra, directivity, and acoustic pressure spectra were compared with the best available data. These data were for noise caused by a fan exit duct annular splitter ring, larger-chord stator blades, and turbine exit struts.

78-1677

Space Harmonics Evaluation and Dynamic Behaviour Prediction of a Wound-Rotor Induction Motor

M. Fafian

Dept. of Electrical Engrg., Pahlavi Univ., Shiraz, Iran, J. Franklin Inst., 305 (5), pp 283-291 (May 1978) 6 figs, 1 table, 6 refs

Key Words: Induction motors, Mathematical models

This paper shows the necessary tests and theory to determine the space harmonic coefficients in a phase model of a wound-rotor induction motor. Also, it demonstrates how the harmonics affect the performance of the motor during a steady-state or transient operation by utilizing the dynamic phase model and the obtained phase parameters. The test on a motor of this type supports the theoretical results obtained from the proposed model.

ROAD

(Also see Nos. 1557, 1654, 1655)

78-1678

Predicting Crush Response of Automotive Structural Components

C. Ni and D.S. Fine

Engrg. Mechanics Dept., General Motors Res. Labs., SAE Paper No. 780671, 12 pp, 13 figs, 10 refs

Key Words: Collision research (automotive), Crashworthiness, Computer programs, Finite difference theory, Nonlinear theories

An analytical technique presented in this paper provides the capability to predict the crush response of certain automotive structural components. This technique was coded from the finite difference formulation to solve the highly nonlinear equations of motion of the structural components when subjected to large deformation. It is operational for production usage. As a production program, it has extensive user convenience such as interactive computer graphics in model generation, model editing, and output display. For the purpose of demonstration, four problems solved by using this program are reported in this paper.

78-1679

Mathematical Modeling of Occupant Biomechanical Stress Occurring During a Side Impact

W. Schmid

Daimler-Benz AG, Stuttgart, Germany, SAE Paper No. 780670, 16 pp, 26 figs, 3 refs

Key Words: Collision research (automotive), Impact response, Mathematical models

After the frontal impact, the side impact is the next most dangerous frequently occurring accident mode, accounting for approximately 25% of all injuries and fatalities. Safety research, therefore, endeavors to determine those parameters of the side impact event, which have a decisive influence on the risk of injury to the occupants. Two parameters are the structural rigidity of the impacting vehicle and of the impacted vehicle. Using a very simply mathematical model the possibilities of vehicle compatibility in side impacts are being investigated in order to reduce the likelihood of injury to the lowest possible level.

78-1680

Digital Simulation Analysis for Evaluating Earth Berm Design and Vehicle Dynamics

B.K. Huang and K.H. Kim

North Carolina State Univ., Raleigh, NC, Rept. No. ERSD-110-74-1, FHWA/NC-75/110, 125 pp (June 1975)

PB-277 775/3GA

Key Words: Highway transportation, Interaction: vehicle-terrain, Computer aided techniques, Digital simulation

This study deals with the evaluation and modification of the original North Carolina earth berm based on the generalized vehicle dynamic analysis and computer-aided design using digital simulation techniques. Simulation runs of vehicle-berm interaction were made on both main and transition sections of the original N.C. and the modified berm.

78-1681

Nondestructive Pavement Evaluation

B.M. Das

Civil and Environmental Engrg. Dev. Office, Tyndall AFB, Rept. No. CEEDO-TR-77-41, 22 pp (Oct 1977) AD-A052 707/7GA

Key Words: Runways, Pavements, Nondestructive testing

Research has been in progress for about 10 years to develop a compatible pavement evaluation procedure for airfields based on nondestructive tests. A successful nondestructive pavement evaluation technique will reduce the time of closure of various airfield facilities needed to conduct destructive tests required for conventional pavement evaluation. This study provides a comparison of the projected pavement life of several airfield features estimated by nondestructive and destructive pavement evaluation procedures.

78-1682

On the Noise Emitted by Single Vehicles at Roundabouts

P.T. Lewis and A. James

Welsh School of Architecture, Univ. of Wales, Inst. of Science and Tech., Cardiff CF1 3BA, Wales, J. Sound Vib., 58 (2), pp 293-299 (May 22, 1978) 3 figs, 1 table, 4 refs

Key Words: Motor vehicles, Noise generation

The results of roadside measurements of the noise emitted by 6471 vehicles accelerating from and decelerating towards roundabouts are reported. Three rural sites were used at which speed limits of 50, 60 and 70 mph, respectively, were in operation and where the traffic was freely flowing upstream of the roundabout. The vehicles were divided into two groups: light vehicles (less than 1525 kg unladen weight) and heavy vehicles. The measured noise levels are expressed in terms of the distance of the vehicles from the roundabout. It was found that, for both accelerating and decelerating vehicles, the noise level/distance relationships were largely determined by the free flow speeds upstream of the intersection.

ROTORS

(Also see Nos. 1521, 1586, 1587, 1664, 1665, 1699)

78-1683

The Importance of Unsteady Aerodynamics in Rotor Calculations

G.H. Byham and T.S. Beddoes

Westland Helicopters Ltd., Yeovil, UK, In: AGARD Unsteady Aerodyn., 23 pp (Feb 1978) N78-22064

Key Words: Flutter, Rotors, Mathematical models

The aerodynamic model required for rotor calculation methods is described. The impact of compressibility and dynamic stall on the limiting behavior of the rotor is discussed and it is shown, particularly for the condition of stall flutter, that the interaction of blades with discrete tip vortices is a major factor in controlling the blade torsional motion. It is indicated that wake distortion, particularly in the vertical plane, is necessary for detailed calculation of stall flutter.

SHIP

78-1684

Vibratory Forces on a Simulated Hull Surface Produced by Transient Propeller Cavitation

F.M. Lewis and J.E. Kerwin

Dept. of Ocean Engrg., Massachusetts Inst. of Tech., Cambridge, MA, J. Ship Res., 22 (2), pp 89-93 (June 1978) 7 figs, 1 table, 9 refs

Key Words: Ship hulls, Propeller-induced excitation, Cavitation

An experimental setup is described for the measurement of propeller-induced vibratory force on a simulated segment of hull surface located above a model propeller operating in a water tunnel. Measurements are made of the influence of transient cavitation induced by a wake screen on the vibratory force. These experiments confirm recent observations that, in many cases, hull vibratory excitation is completely dominated by transient propeller cavitation.

78-1685

Static and Dynamic Analyses of the LSES Hull Structure

A.S. Hananel, E.J. Dent, E.H. Phillips, and S.H. Chang

Bell Aerospace Co., Div. of Textron, Inc., New Orleans, LA, J. Ship Res., 22 (2), pp 110-122 (June 1978) 20 figs, 6 tables, 8 refs

Key Words: Ship hulls, Finite element technique, NASTRAN (computer program), Computer programs

To avoid the conservativeness in the large surface-effect ship hull design which results from simplifying assumptions in the stress analysis, the hull structure was analyzed as a three-dimensional elastic body. The NASTRAN finite-element program, level 15.0, was selected for use in this analysis as the most suitable program available. A finite-element model representing the true hull stiffness was used in obtaining the internal load and displacement distributions. The inertia effect of the ship masses was included with each set of static loads. This was done by using the Static Analysis with Inertia Relief solution included in NASTRAN. The stress redistribution around cutouts in the hull was treated in a separate study. The interection between hull and deckhouse was investigated by attaching a model of the

deckhouse onto the hull model, and then solving for the appropriate load conditons. The natural frequencies were obtained using a reduced finite-element model of both the hull and hull/deckhouse combination. A new technique was developed for determining the dynamic stresses and their proper superposition on the static stresses.

SPACECRAFT

(Also see Nos. 1575, 1576, 1577, 1578, 1619)

78-1686

Needs and Trends in Structural Dynamics

G. Morosow, M. Dublin, and E.E. Kordes

Martin Marietta Aerospace, Astronaut. & Aeronaut., 16 (7/8), pp 90-94 (July/Aug 1978) 4 refs

Key Words: Spacecraft, Dynamic structural analysis, Dynamic tests

This article covers dynamic analyses of aerospace vehicles, dynamic testing of aerospace vehicles, application of dynamic analyses and testing to nonaerospace fields, education of dynamicists, and related surveys. Items covered in the dynamic analyses of aerospace vehicles include self-induced and forced oscillatory loads, approaches to dynamic modeling and analysis, nonlinear analyses, integrated dynamics design and optimization, and other pertinent topics (i.e., requiring improvements in accuracy of analysis to improve performance and reduce costs).

78-1687

Static and Dynamic Stability Analysis of the Space Shuttle Vehicle-Orbiter

W.J. Chyu, R.K. Cavin, and L.L. Erickson

Ames Res. Center, NASA, Moffett Field, CA, Rept. No. NASA-TP-1179; A-7217, 62 pp (Mar 1978) N78-20176

Key Words: Spacecraft, Space shuttles, Computer programs

The longitudinal static and dynamic stability of a Space Shuttle Vehicle-Orbiter (SSV Orbiter) model is analyzed using the FLEXSTAB computer program. Nonlinear effects are accounted for by application of a correction technique in the FLEXSTAB system: the technique incorporates experimental force and pressure data into the linear aerodynamic theory.

78-1688

Cushioned Hydraulic Cylinders Simulate Space Shuttle Launch

L. Boni

Cylinder Div., Parker Hannifin Corp., Des Plaines, IL, Hydraulics & Pneumatics, 31 (5), pp 69-72 (May 1978) 4 figs

Key Words: Launching, Simulation, Space shuttles

Two high-speed, self-decelerating, 1000-hp hydraulic cylinders for use in a NASA simulator are described. They duplicate the complex lift-off accelerations, forces, and speeds of the Space Shuttle.

78-1689

ESA's Activities in the Fields of Dynamics and Technology Related to the Presence of Liquids On-Board Spacecraft

J.L. Cendral and W. Berry

Attitude and Orbit Control Div., European Space Res. and Tech. Center, Noordwijk, Netherlands, In: ESA Attitude Control of Space Vehicles: Technol. and Dyn. Probl. Assoc. with the Presence of Liquids, pp 9-21 (Dec 1977)
N78-20179

Key Words: Spacecraft, Fluid-induced excitation, Sloshing

The presence of significant amounts of liquids onboard spacecraft raises problems in two areas: the design of the containers for effective management of the liquids in the presence of satellite motion, and the dynamic interaction between liquid and satellite motion with consequent design impacts on the attitude control systems. ESA's past and current activities in these domains are presented. In particular, the experience on the dynamics of unstable spinning satellites, liquid type nutation dampers, and bipropellant apogee boost motors are discussed. The Agency's activities in the development of positive expulsion and surface tension propellant tanks to be used for three axis stabilized missions are summarized. Future aspects of the problems as they appear to be modified by technological trends and new developments for future spacecraft are discussed.

78-1690

Attitude Control of Space Vehicles: Technological and Dynamical Problems Associated with the Presence of Liquids

J.L. Cendral, J.L. Marce, and T.D. Guyenne

European Space Agency, Paris, France, Rept. No. ESA-SP-129, 218 pp (Dec 1977)
N78-20178

Key Words: Spacecraft, Fluid-induced excitation, Sloshing

The dynamic aspects of fluid satellite interaction were discussed, the two main themes being the influence of the presence _ luids on both controlled and uncontrolled satellite motions, and the effect of satellite motions on the management of the fluids and the possible perturbation of their functions. The five sessions and the round table discussions were devoted respectively to: satellite propulsion-system tanks (particularly capillary and positive-expulsion tanks); spin dynamics; three-axis dynamics; stability; liquid nutation dampers.

78-1691

Stability of Orbiting Sapcecraft in Presence of Liquids

P. Santini and R. Barboni

Inst. of Aerospace Tech., Rome Univ., Italy, In: ESA Attitude Control of Space Vehicles: Technol. and Dyn. Probl. Assoc. with the Presence of Liquids, pp 131-139 (Dec 1977)

N78-20190

Key Words: Spacecraft, Sloshing, Liquid propellants

The dynamic behavior of a satellite, consisting of a rigid structure with cavities with a sloshing fluid, was studied. The fluid motion is described for each cavity, via sloshing modes; furthermore, rigid motion parameters are introduced. Solving equations include free surface conditions and dynamic equations, in translation and rotation. A discussion on sloshing modes is presented. Numerical examples are given.

78-1692

Dynamics of Spinning Spacecraft Containing Various Revolving Filled Eccentric Tanks (Dynamique D'un Vehicule Spatial Contenant Plusieurs Reservoirs de Revolution Pleins Excentres en Autorotation)

A. deBerranger

Societe Europeene de Propulsion, Vernon, France, In: ESA Attitude Control of Space Vehicles: Technol. and Dyn. Probl. Assoc. with the Presence of Liquids, pp 157-163 (Dec 1977)

(In French)

N78-20192

Key Words: Spacecraft, Storage tanks, Sloshing

The influence of the eccentricity of revolving tanks that are completely filled on the stability of spinning spacecraft was analyzed. Both for ideal and for viscous liquids the problem was reduced to the classical case of the single central tank. In the nonviscous case the equations describing the dynamics of the total system were derived from the free inertial liquid modes occurring when the nutation of the vehicle is blocked. Remarkable properties resulting from the mathematical structure of the system and from its coefficients were shown. The results were verified whenever possible using the spherical tank.

78-1693

Effect of Attitude Control Thruster Induced Structural Vibrations on Sensed Accelerations of a Space Vehicle

T.A. Butler

Los Alamos Scientific Lab., Los Alamos, NM, Rept. No. LA-6965-MS, 41 pp (Sept 1977)

N78-21201

Key Words: Spacecraft equipment response, Equations of motion, Linear theories, Computer programs

The response of a miniature electrostatic accelerometer (MESA) to the structural vibrations of a space vehicle (SV) is determined analytically. Knowledge of these vibration-induced accelerations will be used to interpret the total MESA accelerations that will be obtained while the SV is in orbit. Equations of motion containing nonlinear terms are solved to show that a linear analysis approach will yield sufficient accuracy. A Laplace transform technique is then used to solve the linearized equations, which are decoupled using the normal vibration modes of the SV. A computer program is developed to solve the equations of motion. It includes frequency attenuation and sampling interval characteristics of the MESA and equivalent viscous damping for the SV vibratory modes. The calculated MESA response to 1800's of actual thruster excitation is presented.

STRUCTURAL

78-1694

A Two Degree of Freedom Model for the Dynamics of Offshore Structures

R.E. Taylor

Dept. of Mech. Engrg., Univ. College London, UK, Intl. J. Earthquake Engr. Struc. Dynam., 6 (4), pp 331-346 (July/Aug 1978) 10 figs, 8 refs

Key Words: Offshore structures, Concretes, Mathematical models

As a means towards an understanding of the structural dynamics of deepwater gravity platforms, the dynamic response of a linear two degree of freedom spring-mass-damper system is studied herein. The mathematical model represents dynamic interaction between structure and foundation. Particular attention is paid to the influence of wave force distribution. Transfer functions are obtained for the response to sinusoidal waves, and resonant magnification factors are plotted for a range of structural and loading parameters. It is concluded that the response even of this simple idealization is far from straightforward.

78-1695

Parametric and Nonlinear Mode Interaction Behaviour in the Dynamics of Structures

A.D.S. Barr and R.P. Ashworth

Dept. of Mech. Engrg., Dundee Univ., UK, Rept. No. AFOSR-TR-78-0416, 90 pp (Dec 1977)

AD-A052 005/6GA

Key Words: Harmonic excitation, Resonant response, Parametric response, Nonlinear analysis

The report is concerned with the resonant behavior of general structural systems under single frequency harmonic excitation. In particular it is concerned with the parametric and nonlinear phenomena which arise when there are certain integral relationships between the excitation frequency and some of the natural frequencies of the structure (external resonance), and among the natural frequencies themselves (interval resonance).

TRANSMISSIONS

(Also see Nos. 1529, 1660)

78-1696

Transmission Design with Finite Element Analysis: Part 3

R.W. Howells

Power Transm. Des., 20 (6), pp 56-57 (June 1978) 4 figs, 1 ref

Key Words: Power transmission systems, Helicopter engines, Finite element technique, Design techniques

A transmission design using finite element methods is described. A computer model of the CH-47 helicopter forward rotor transmission is applied to optimize transmission design. The current effort is concentrated in two areas -- to minimize overall vibration and noise levels and to optimize the housing structural design.

USEFUL APPLICATION

78-1697

Vibration of Unreinforced Pavement Concrete

R.G. Phillips

Engrg. Res. and Dev. Bureau, New York State Dept. of Transportation, Albany, NY, Rept. No. RR-78-59, FHWA/NY-78/RR/59, 15 pp (Mar 1978)

PB-279 148/1GA

Key Words: Vibrators (machinery), Concretes, Pavements

The interim report for this research project indicated that a substantial amount of vibration is transmitted to pavement concrete by the mesh and mesh depressors. When plain (unreinforced) pavements were specified, concern arose over the possibility of insufficient consolidation.

78-1698

Vibration Responsive Switch

J.H. Watson

Dept. of the Navy, Washington, D.C., Rept. No. AD-D004 736/5, PAT-APPL-326 649, 6 pp (Mar 8, 1977)

PATENT-4 011 418

Key Words: Electrical

The vibration responsive switch is comprised of a mass, a pair of support structures located on opposite sides of said mass, a taut wire attached to both of said support structures and to said mass, a switch armature mounted on said mass, and a fixed contact located in physical proximity to said armature.

78-1699

Acoustic Driving of Rotor

H. Kanber, I. Rudnick, and T.G. Wang

NASA, Pasadena, CA, Rept. No. NASA-Case-NPO-14405-1, US-Patent-Appl-SN-812447, 9 pp (July 1977)

N78-22859

Key Words: Rotors, Propulsion systems, Acoustic techniques

The object of the invention is to provide a system for utilizing sound to rotate a suspended object, with large and controlled torque. An enclosure of square cross-section is utilized together with transducers at walls which are at right angles to each other. A circuit drives the transducers at the same frequency, but at a constant phase difference such as 90 deg. This causes rotation of air molecules and therefore, rotation of a shaft which extends through the enclosure, as a first order effect.

AUTHOR INDEX

TECHNICAL NOTES

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Intl. J. Earthquake Engr. Struc. Dynam., 6 (3), pp 317-320 (May/June 1978) 2 tables, 7 refs

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B.M. Karmakar
Nonlinear Vibrations of Orthotropic Plates Carrying Concentrated Mass
J. Engr. Indus., Trans. ASME, 100 (2), pp 293-294 (May 1978) 1 fig, 6 refs

NOVEMBER 1978

26-Dec 1 Acoustical Society of America, Fall Meeting, [ASA] Honolulu, Hawaii *(ASA Hq.)*

27-30 Aerospace Meeting, [SAE] Town & Country, San Diego, CA *(SAE Meeting Dept., 400 Commonwealth Dr., Warrendale, PA 15096 - Tel. (412) 776-4841)*

DECEMBER 1978

4-6 15th Annual Meeting of the Society of Engineering Science, Inc., [SES] Gainesville, FL *(Prof. R.L. Sierakowski, Div. of Continuing Education, Univ. of Florida, 2012 W. University Ave., Gainesville, FL 32603)*

10-15 Winter Annual Meeting, [ASME] San Francisco, CA *(ASME Hq.)*

11-14 Truck Meeting, [SAE] Hyatt Regency, Dearborn, MI *(SAE Meeting Dept., 400 Commonwealth Dr., Warrendale, PA 15096)*

FEBRUARY 1979

26-Mar 2 Congress & Exposition, [SAE] Cobo Hall, Detroit, MI *(SAE Meetings Dept., 400 Commonwealth Dr., Warrendale, PA 15096)*

APRIL 1979

30-May 2 NOISE-CON 79, [INCE] Purdue University, IN *(NOISE-CON 79, 116 Stewart Center, Purdue University, West Lafayette, IN 47907 - Tel. (317) 749-2533)*

30-May 2 Environmental Sciences Meeting, [IES] Seattle, WA *(Dr. Amiram Roffman, Energy Impact Assoc., Inc., P.O. Box 1899, Pittsburg, PA 15230 - Tel. (412) 256-5640)*

30-May 3 1979 Offshore Technology Conference, [ASME] Astrodomain, Houston, TX *(ASME Hq.)*

MAY 1979

20-25 Spring Meeting and Exposition, [SESA] San Francisco, CA *(SESA, 21 Bridge Square, P.O. Box 277, Saugatuck Sta., Westport, CT 06880 - Tel. (203) 227-0829)*

JUNE 1979

12-16 Acoustical Society of America, Spring Meeting, [ASA] Cambridge, MA *(ASA Hq.)*

SEPTEMBER 1979

10-12 ASME Vibrations Conference, [ASME] St. Louis, MO., *(ASME Hq.)*

10-13 Off-Highway Meeting and Exposition, [SAE] MECCA, Milwaukee, WI *(SAE Meeting Dept., 400 Commonwealth Dr., Warrendale, PA 15096)*

11-14 INTER-NOISE 79, [INCE] Warsaw, Poland *(INTER-NOISE 79, IPPT PAN, ul. Swietokrzyska 21, 00-049 Warsaw, Poland)*

OCTOBER 1979

7-11 Fall Meeting and Workshops, [SESA] Mason, OH *SESA, 21 Bridge Square, P.O. Box 277, Saugatuck Sta., Westport, CT 06880 - Tel. (203) 227-0829)*

NOVEMBER 1979

4-6 Diesel and Gas Engine Power Technical Conference, San Antonio, TX *(ASME Hq.)*

5-8 Truck Meeting, [SAE] Mariott, Ft. Wayne, IN *(SAE Meeting Dept., 400 Commonwealth Dr., Warrendale, PA 15096)*

26-30 Acoustical Society of America, Fall Meeting, [ASA] Salt Lake City, UT *(ASA Hq.)*

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CALENDAR ACRONYM DEFINITIONS AND ADDRESSES OF SOCIETY HEADQUARTERS

AFIPS: American Federation of Information Processing Societies
210 Summit Ave., Montvale, NJ 07645

AGMA: American Gear Manufacturers Association
1330 Mass. Ave., N.W.
Washington, D.C.

AHS: American Helicopter Society
1325 18 St. N.W.
Washington, D.C. 20036

AIAA: American Institute of Aeronautics and Astronautics, 1290 Sixth Ave.
New York, NY 10019

AIChE: American Institute of Chemical Engineers
345 E. 47th St.
New York, NY 10017

AREA: American Railway Engineering Association
59 E. Van Buren St.
Chicago, IL 60605

AHS: American Helicopter Society
30 E. 42nd St.
New York, NY 10017

ARPA: Advanced Research Projects Agency

ASA: Acoustical Society of America
335 E. 45th St.
New York, NY 10017

ASCE: American Society of Civil Engineers
345 E. 45th St.
New York, NY 10017

ASME: American Society of Mechanical Engineers
345 E. 47th St.
New York, NY 10017

ASNT: American Society for Nondestructive Testing
914 Chicago Ave
Evanston, IL 60202

ASQC: American Society for Quality Control
161 W. Wisconsin Ave.
Milwaukee, WI 53203

ASTM: American Society for Testing and Materials
1916 Race St.
Philadelphia, PA 19103

CCCAM: Chairman, c/o Dept. ME, Univ. Toronto, Toronto 5, Ontario, Canada

ICF: International Congress on Fracture
Tohoku Univ.
Sendai, Japan

IEEE: Institute of Electrical and Electronics Engineers
345 E. 47th St.
New York, NY 10017

IES: Institute of Environmental Sciences
940 E. Northwest Highway
Mt. Prospect, IL 60056

IFToMM: International Federation for Theory of Machines and Mechanisms, US Council for TMM, c/o Univ. Mass., Dept. ME
Amherst, MA 01002

INCE: Institute of Noise Control Engineering
P.O. Box 3206, Arlington Branch
Poughkeepsie, NY 12603

ISA: Instrument Society of America
400 Stanwix St.
Pittsburgh, PA 15222

ONR: Office of Naval Research
Code 40084, Dept. Navy
Arlington, VA 22217

SAE: Society of Automotive Engineers
400 Commonwealth Drive
Warrendale, PA 15096

SEE: Society of Environmental Engineers
6 Conduit St.
London W1R 9TG, UK

SESA: Society for Experimental Stress Analysis
21 Bridge Sq.
Westport, CT 06880

SNAME: Society of Naval Architects and Marine Engineers, 74 Trinity Pl.
New York, NY 10006

SPE: Society of Petroleum Engineers
6200 N. Central Expressway
Dallas, TX 75206

SVIC: Shock and Vibration Information Center
Naval Research Lab., Code 8404
Washington, D.C. 20375

URSI-USNC: International Union of Radio Science - US National Committee c/o MIT Lincoln Lab.,
Lexington, MA 02173

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